THE HAWAIIAN PLANTERS' RECORD

Volume XXIV. JANUARY, 1921 Number 1

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Sugar Prices for 1918, 1919 and 1920.

The "Record" formerly published in each issue the sugar prices for a period of one month prior to the time of going to press.

During 1918 when the price of sugar was under governmental supervision, there being no fluctuations to report from month to month, the practice of reporting prices was discontinued.

We have been asked to resume the publication of sugar prices. The last quotation we gave was that of November 14, 1918, 6.055 cents per pound or $120.10 per ton.

The Food Control Act became effective August 10, 1917. It contained no provision for price fixing of sugar. The price of sugar was controlled, however, by the Food Administrator through voluntary cooperation of the various producers.

Agreements in this connection began with beet sugar producers in August, 1917. Other arrangements were made with the Louisiana producers. In December the price was fixed at 6.005 cents per pound by the direct purchase of the whole 1917-18 crop of Cuba by the International Sugar Committee, this price applying to Hawaiian sugars January 2, 1918. On June 24, 1918, the price was raised to 6.055 cents owing to the increased cost of war risk insurance.

Beginning with the new crop, December 22, 1918, the price was advanced to 7.28 cents per pound for Hawaiian sugars. This price remained unchanged throughout the year 1919.

With the return to open market conditions in 1920, Hawaiian sugar began with the price of 12.29 cents on January 5, 1920. The highest price of the year, 23.57 cents, was reached May 19, and the lowest, 4.63, on December 14.

The prices applying to Hawaiian raw sugar are here shown in detail for the years 1918, 1919, and 1920, with the date of each fluctuation:

	96° Centrifugals per lb.	96° Centrifugals per ton
1918		
Jan. 2*	6.005¢	$120.10
June 24	6.055	121.10
Dec. 22	7.28	145.60
1919		
No change from the quotation of Dec. 22, 1918.		
1920		
Jan. 5	12.29¢	$245.80
" 6	12.04	240.80
" 7	12.915	258.30
" 10	13.04	260.80
Feb. 5	12.79	255.80
" 7	12.54	250.80
" 9	12.165	243.30
" 16	11.03	220.60
" 26	10.28	205.60
Mar. 2	11.29	225.80
" 3	11.54	230.80
" 9	11.03	220.60
" 12	11.29	225.80
" 15	11.54	230.80
" 17	11.79	235.80
" 18	12.04	240.80
" 19	12.415	248.30
" 20	12.54	250.80
' 22	12.79	255.80
" 27	12.915	258.30
" 29	13.04	260.80
April 5	15.30	306.00
" 10	17.43	348.60
" 14	18.56	371.20
" 16	19.185	383.70
" 17	19.56	391.20
May 13	21.06	421.20
" 14	21.57	431.40
" 17	22.57	451.40
" 18	23.07	461.40
" 19	23.57	471.40
" 26	22.57	451.40
" 27	20.56	411.20
June 3	20.31	406.20
" 7	20.06	401.20
" 16	19.685	393.70

* The previous fluctuation was December 28, 1917, when the price changed from 6.0025¢ to 6.00¢.

"	17	19.56	391.20
"	29	18.31	366.20
July	6	18.56	371.20
"	16	18.31	366.20
"	20	17.81	356.20
"	21	16.80	336.00
"	26	16.30	326.00
Aug.	9	15.80	316.00
"	12	13.04	260.80
"	19	12.04	240.80
Sept.	13	10.78	215.60
Oct.	6	8.78	175.60
"	15	8.03	160.60
"	26	8.26	165.20
"	27	8.485	169.70
"	29	8.39	167.80
"	30	8.145	162.90
Nov.	3	8.01	160.20
"	5	7.515	150.30
"	9	7.265	145.30
"	10	7.02	140.40
"	11	7.015	140.30
"	12	6.64	132.80
"	13	6.51	130.20
"	15	6.515	130.30
"	16	6.52	130.40
"	18	6.26	125.20
"	19	5.955	119.10
"	22	5.76	115.20
"	23	5.77	115.40
"	26	5.76	115.20
Dec.	3	5.77	115.40
"	7	5.51	110.20
"	8	5.32	106.40
"	10	5.01	100.20
"	13	4.76	95.20
"	14	4.63	92.60
"	18	5.01	100.20
"	21	5.14	102.80
'	22	5.38	107.60
"	23	5.426	108.52
"	27	5.31	106.20
"	28	5.32	106.40

H. P. A.

Some Fundamental Requirements of Plants.*

By A. L. Dean.

The objects of the universe around us fall naturally into two great groups—the living and the non-living. The living organisms are distinguished by at least three characteristics: their capacity for growth whereby forms resembling the parents are built up through incorporation of materials contained in food, the capacity for reproduction, and the power of response to stimuli. With all the wide dissimilarities between the many forms of living organisms, there run through the whole series similarities in requirements. We find with all of them a sensitiveness to certain physical factors of their environment, of which temperature perhaps is the most important, a necessity for oxygen, for water and for food.

The different groups of plants and animals have developed along different lines in their solutions of the problems of securing these fundamental requirements. For example, we find that in a general way the plants secure their food supply by passive means, whereas the animals have developed powers of searching for food and for seizing it when they find it. It is an interesting study to compare the different types of plant and animal forms with the idea in view of noting how each has solved in some ingenious fashion the problem of securing its fundamentally important supplies.

Temperature.

Turning our attention to the higher plants and more especially the crop plants, we shall find a knowledge of their basic requirements is a starting point for the understanding of agricultural practice. Considering first the matter of temperature, we find plants to have a very wide vital range, running from just above the freezing point to about 120° F. In the range of temperature through which any given plant can function we can distinguish the minimum temperature as that lowest point at which life proceeds, the maximum temperature as the highest one which the plant can survive, and the optimum temperature as that best suited for its life processes. If we look into the matter a bit closer we shall find that these points are not the same for each of the different functions of the plant; that, for example, the temperature at which photosynthesis goes on to the best advantage is not likely to be the one at which respiration is the most active.

Plants resemble the group of the cold-blooded animals much more closely than they do the warm-blooded animals. With these latter we find that the tissues of the body are able to live only within a very narrow range. In the case of our own bodies we know that a slight rise above the normal temperature means fever and a slight falling below is a danger signal of failing vitality. We have developed an elaborate system for maintaining the temperature of the body tissues within very narrow limits so that, although taking our bodies as a whole we can

* A lecture given at the Short Course for Plantation Men, University of Hawaii, October, 1920.

endure great changes in the surrounding temperature, these changes are not communicated to the interior of our bodies to any notable degree, and if they are so communicated, death follows. In the case of the plants and the cold-blooded animals on the other hand, the temperature of the tissues of the organism tends to follow that of the surroundings. Some regulation of temperature there is, but it is slight indeed compared with the elaborate machinery and great accuracy of adjustment of the warm-bodied animals.

The plant has certain sources of heat, notably that which comes from within through the process of respiration, and that which comes from without in the form of the radiant energy from the sun. At the same time heat is being lost by transpiration which involves the evaporation of water and is especially active in the leaves, and by radiation from the whole surface of the plant body. The resultant of these more or less conflicting factors is a temperature within the plant which is commonly not the same as the temperature of the atmosphere, but on the other hand does not vary so very widely from it, nor is it maintained in any degree of uniformity. This means, of course, that the growth of the plant in so far as it is regulated by temperature is closely dependent upon the atmospheric conditions and that the effects of these cannot be overcome by variations in the food supply.

OXYGEN.

Everyone recognizes that animals require oxygen and that the terrestrial animals get this from the air and the aquatic animals get it from the oxygen which is dissolved in the water. It is less commonly recognized that plants are likewise dependent upon a supply of oxygen and that this almost invariably is derived either directly or indirectly from the air. A few very lowly forms of plants belonging for the most part in the group of the bacteria do not require air, and, indeed, some of them have their growth hindered or stopped by its presence. With this minor exception, however, all plants are as dependent upon oxygen as are the animals. In the case of our crop plants we find that leaves are provided with an elaborate system for allowing air to enter and circulate and that a very substantial portion of the leaf tissue consists of air spaces. This inter-cellular space system in the leaves communicates with the outside atmosphere through numerous stomata or minute openings in the leaves' surfaces. With some plants these are found only on the under surfaces, with others on both under and upper surfaces. They vary greatly in number, but are exceedingly numerous in most plants. They are so constructed that they are capable of opening and closing with variations in the water supply of the plant. The stems of the herbaceous plants are also provided with stomata, although in much smaller numbers than the leaves. The stems of woody plants have a different mechanism for accomplishing this same process of aeration. With the roots we find that there are no openings for allowing air to enter, but that the oxygen is absorbed from solution in the soil water. This soil moisture in its turn must secure this dissolved oxygen through contact with air in the spaces of the soil, hence the necessity for a proper aeration of the soil and one of the chief reasons why densely-packed and waterlogged soils give such poorly-developed or diseased root systems. Although the highly developed aerating system of the leaves is required for another

purpose, as well as that of respiration, yet its importance in relation to this function cannot be overlooked. We find throughout the whole plant body that wherever there are actively living cells, there is the demand for oxygen which must be met by some contrivance or other. The amount of oxygen required by growing plants is often very large. With things which are growing actively, such, for example, as germinating seeds, the amount demanded will equal or exceed the amount required by man per unit of weight. With some of the microscopic forms which are reproducing with great rapidity an oxygen requirement as high as 200 times as much as that of man per unit weight has been recorded. This consumption of oxygen is directly related to the means of securing the energy required for carrying out the life processes.

It is difficult for us to realize that in the quiet and hidden processes of growth going on within the plant there is a demand for the expenditure of energy. We are accustomed to think of energy in its more evident and spectacular form. It is true, nevertheless, that these invisible processes are great consumers of energy, and it is just as true in the plant body as it is in the field of engineering that you cannot get energy except from some source which is supplied from the outside. In the case of plants as in that of animals the required energy is furnished through the oxidation of substances within the body by a process which we may call physiological combustion to distinguish it from the ordinary and violent form. Just as we must have air for the combustion of fuel in our furnace, so too we must have oxygen for the processes of oxidation, with their accompanying energy release, which are going on inside the plant and animal bodies.

It follows from these general considerations that wherever we have a living cell there we must have a supply of oxygen. The products which result for the most part from these processes are carbon dioxide and water, the ordinary oxidation products of carbon and hydrogen. We call this process whereby the potential energy of chemical compounds within the body is set free for physiological uses, respiration. Our ordinary notion of respiration is the process of drawing air in and out of the lungs of the higher animals. Even in the case of these animals, however, this is but the beginning and ending of a process. It is the drawing in of oxygen from the outside and the return of carbon dioxide gas and water vapor which have resulted from the utilization of this oxygen throughout the entire body. The true process of respiration is going on in all tissues; in the muscles, and glands, and nervous system; wherever, in short, there is active cell life. If we accustom ourselves to this view of respiration we shall see that it is equally appropriate to the analogous chemical processes which are going on in the plant body, even though we do not have the drawing in and expelling of gases by obvious muscular activity.

Water.

Not only are all living organisms dependent upon oxygen derived either directly or indirectly from the atmosphere; they are also dependent upon an adequate supply of water. The actively living parts of plants and animals consist of water as their chief ingredient. The ordinary animal muscle is approximately 80% water, and the actively growing parts of plants, such as young roots

and leaves, are usually over 90% water. Of course, there are parts of animal bodies and parts of plant bodies which contain relatively small amounts, but these are the parts which are not actively growing, or which, like the bone, are designed for some special purpose where rigidity is the principal consideration.

Everyone knows that if a sufficient supply of water is cut off from a plant it will wilt. This wilting is due to the evaporation of the water away from the more tender parts of the plant without a sufficient supply being brought in to take its place. The firmness of the ordinary leaf and stem is due to the fact that all of the cells of which they are composed are stretched with water, and this mass of tightly-stretched cells has the firm, more or less rigid character of the healthy plant. Another important use of water in the plant is as a medium for entrance of the plant's food materials. We have already noted that the gases enter into the inter-cellular spaces of the aerial parts of plants through minute openings through which the gases can circulate. When they are in this inter-cellular space, however, they are not yet inside the cells. The gases which are used must dissolve in the moisture which saturates the cell walls adjacent to these inter-cellular spaces, and it is in the form of dissolved gases that they finally reach the actual living parts within.

When we examine the root systems of plants we find that they present an unbroken surface. There are no small mouths or openings through which the water of the soil with its dissolved nutrients can enter. Everything has to pass through the walls of the cells on the outside of the roots, and that means that everything passes dissolved in water. Thus the fertilizers which we use on the soil and the materials of the soil itself must first dissolve in the soil water and in the form of solution pass through the membranes of the roots and thence into the other parts of the plant. Not only do these food materials enter dissolved in water, but they move about the plant in solution, and the substances which the plant has itself elaborated, such, for example, as sugar, pass from one part of the plant to another dissolved in water.

There is an ascending current of water, carrying substances in solution, which rises from the roots to the leaves. The speed of this current varies greatly according to the kind of plant and the conditions under which it is growing. It may go a few inches per hour; it may go a number of feet. The water which rises in this current is evaporated from the leaf cells into the inter-cellular spaces and passes out through the stomata in the form of water vapor. This process by which the water evaporates from these cells and thence escapes to the outer air is called transpiration and the rising current of water from root to leaves is frequently spoken of as the transpiration current. The plant exercises some degree of control over this, since one of the first manifestations of insufficient supply of water will be the closing of the guard cells of the stomata. This cuts down the transpiration and tends to ward off the evil effects of the restricted water supply. But closing the stomata interferes with other processes besides that of transpiration and the whole vigor of the plant's growth is seriously handicapped.

One of the effects attendant upon this evaporation of water through leaves is the cooling due to the change of state from the liquid to gaseous water. This is undoubtedly an important matter when leaves are exposed to the light and heat of the tropics. Some plants are able to stand this high temperature without

serious injury, but others are only able to endure it when they have a bountiful supply of water for their root systems. If the process of transpiration is once stopped in these more tender plants and the leaves wilt, they never recover.

Our ordinary crop plants secure their entire water supply from the soil. It does not follow, however, that the soil with the most water in it is the most advantageous. If the water is present to the exclusion of air in the spaces between the soil particles, the plant will suffer from lack of oxygen. These terrestrial plants have adapted themselves to secure their water supply to best advantage when the soil is not waterlogged, but when the particles which make it up have each a film of water about it. The small rootlets and the minute root hairs with which most young roots are provided are in intimate contact with the particles of soil, so intimate, in fact, that when we uproot a plant and shake it, the rootlets do not appear naked, but have clinging to them coatings of these soil particles between which the roots have grown.

There are great differences in the water-holding capacity of different soils, differences due to the size of the soil particles and the proportion of decaying organic matter mixed with the mineral particles which have been derived from decomposing rocks. The reasons for many of our agricultural practices can be traced to the necessity of maintaining the proper conditions of air and water in the soil, conditions which are absolutely essential if we are to secure the vigorous growth which good agricultural practice calls for.

Physical Properties of Soils.*

By L. A. Henke.

A soil may be defined as a loose and friable material in which plants may and do find a foothold and nourishment as well as other conditions of growth.

Hawaiian soils come from two sources. They are either the results of volcanic eruption or coral growth on the edges of the volcanic islands which must have been formed first. A later upheaval after a coral reef had been formed around the islands could easily result in the coral limestone being brought far inland from the seashore, and a later volcanic eruption might easily cover up the coral reef formed on the fringe of the islands. Evidence abounds that both of these processes did take place, with the result that the lava and coral limestone soils are intimately mixed in many places.

Soil formation is essentially a process of big rocks becoming small due to various factors about to be discussed. Temperature changes play a big part in most parts of the world, although they may be of only minor importance in Hawaii because of our uniform climate. In regions of extreme temperatures and in the mountain peaks in the tropics rocks are continually being split asunder

* Summary of a lecture given at the Short Course for Plantation Men, University of Hawaii, October, 1920.

because the different parts of a complex rock do not expand or contract equally with temperature changes. This is well illustrated on the top of Pike's Peak, in Colorado, and to a lesser degree on the top of Haleakala, on Maui.

Water is a second big factor in breaking up rock particles in such small parts that we term them soils. Flowing water grinds rock particles against each other, and the soluble parts of the rock are dissolved out and deposited in lower regions or carried to the ocean. The cutting and grinding action of water is well illustrated by deep chasms found in our mountains, usually with a stream at the bottom of same, but every little stream that trickles down over a rock is doing exactly the same thing, but on a much smaller scale.

In some parts of the world winds are a big factor in soil formation and mixture. A strong wind will carry little particles of grit which blow against rocks, resulting in gradually cutting away the rock surface. Wind action is probably of little importance in Hawaii, but the "buttes" of Montana are striking monuments to the ability of strong winds to lower the surface of the land to a marked degree. The combined result of both water and wind is to lower the land surface and fill the ocean. Renewed unheavals of the land in various parts of the world from time to time, of course, add to the supply of land above the ocean level.

After rocks are somewhat broken up by the above agencies, or even before, the lowest forms of plant life begin to play a part in soil formation. Lichens will grow on a bare rock with only a little amount of moisture, and their roots secrete such a strong acid, that the rock surface on which they cling is partly dissolved, and mosses and later ferns begin to get a foothold in the rock where some plant food has been made available. Mosses and ferns die and decompose and add a new and vital substance to the soil which we call organic matter. In the decomposition of these plants carbon dioxide is formed and this combines with water to form carbonic acid, which still further dissolves the rock particles. In fact, carbon-dioxide is secreted by the roots of all growing plants, which makes it possible for roots to take plant food out of the soil which pure water could not dissolve. The gas oxygen also plays a big part in soil formation, by combining with parts of rocks to increase their volume, which usually results in splitting of the rock surrounding these oxidized parts.

The above brief description will indicate in a general way how soils are formed and how organic matter is incorporated with them. After they are formed they may remain in their place of origin, as the Wahiawa section on Oahu, in which case they are called residual soils. Or they may partially slide down a mountain side, collecting on the flat slopes, in which case the resultant soils are colluvial. Or they may be picked up by a stream of water flowing at high velocity and dropped out again when the stream decreases its velocity due to its approaching sea level. The fertile delta of the Mississippi river is formed in this way, and such soils are called alluvial.

When all the above has taken place we find that soils consist essentially of four things—rock particles of all sizes, organic matter in all stages of decomposition, water, and forms of life commonly called bacteria.

The rock particles range in size from particles so large that we call them gravel to minute pieces perhaps only 1/25,000 part of an inch in diameter. These

rock particles contain reserve plant food, and some of the plant food immediately available to plants. These rock particles constitute the skeleton or framework of the soil, for the balance of the soil is built around them.

The organic matter consists of the remains of plant and animal life in all stages of decomposition. It finally forms this black or dark-colored, sticky material in the soil that is termed humus. Under certain conditions, such as unusually high temperature, with too open a condition of the soil, organic matter will be completely oxidized, leaving nothing but the ash or mineral constituents behind, and no humus will be formed. This is especially likely to be the case in hot arid sections. In the rainfall sections of the United States it takes about six parts of organic matter to make one part of humus, but in the arid sections of the West it takes twenty parts. It is rather hard to draw a distinct line between organic matter and humus, but for general purposes it may be assumed that when organic matter has decomposed sufficiently so that it is impossible to tell what is was originally, it may be termed humus.

Humus is of great importance in the soil. It coats the rock particles, holding them apart and also cementing them together. Humus contains much of the soil nitrogen, and the ash constituents of the plants or animals from which it is derived. It undoubtedly is a big factor in holding applied fertilizers till the roots of plants can absorb same. Humus holds much of the soil moisture, affects the temperature of soils by making them warmer, gives soils their dark color, absorbs gases, and is of vital importance in providing food material for the bacteria in the soil.

The water content of a soil varies from a few per cent in the case of sands to fifty or more per cent in the case of soils with much organic matter. Half the water-holding capacity of a soil is usually considered most favorable for the growth of plants. The water in soils that is of most use to plants is known as capillary moisture and is held in a film around the soil particles, and always tends to distribute itself equally through the soil by traveling from particle to particle, as coffee travels through a cube of sugar.

Life Conditions in the Soil.*

By L. A. Henke.

Productive soil teems with living organisms which eventually return their bodies to be incorporated in the soil in the form of humus and ash. Among living animals or organisms which spend part or all of their life in the soil may be mentioned burrowing animals, earthworms, ants and insects, molds and fungi and bacteria.

While burrowing animals give the greatest evidence of their presence, they

* Summary of a lecture given at the Short Course for Plantation Men, University of Hawaii, October, 1920.

probably benefit the soil least of any of the life forms found there, because they are usually not very abundant, and if they were abundant they would prove such a nuisance in most respects that we would employ all means available to get rid of them.

Earthworms, however, are of real value in the soil. They loosen, aerate and drain the soil below the plowing depth, and annually pass enough soil through their bodies to leave castings to a depth of about one-fifth inch over the soil surface, if all the work were done in one night so that the combined results could be seen. Darwin says that there are about 25,000 earthworms in an acre of average soil, and that the castings resulting from the soil passing through their bodies make the best kind of fertilizer. Earthworms are found only in soils abundantly supplied with humus, and they can not stand flooding. They live largely on organic matter which they take out of the soil, but inorganic plant food in the soil is made available by the digestive juices of the worm.

Ants and insects spend part of their life cycle in the soil, which results in their bringing much very fine material to the surface each year. Insects which are very destructive to many plants may thus exercise a beneficial influence while they are in the soil.

Fungi and molds are forms of life with a thread-like growth which secure food material from living and dead organic matter in the soil. They are big factors in distributing organic matter and humus through the soil mass.

Germs or bacteria are undoubtedly the most important forms of life found in the soil. They may be helpful, harmful or harmless. They range in numbers from about 50,000 per gram in sandy soil to several million per gram in a rich garden soil. They are most abundant in the first few inches of surface soil, near, but not at the surface. Not many bacteria are found below a two-foot depth, but this will depend largely on the openness of the soil. The best crop yields are usually obtained on soils abundantly supplied with bacteria.

Bacteria need organic matter for their food, and the presence of this determines their abundance. They will live in a wide range of temperatures, but a rather warm soil with optimum moisture content for crop growth is also best for them. The vast majority of bacteria require a slight alkaline reaction in the soil, and practically none thrive in a soil that is distinctly acid.

Bacteria are vitally concerned with the nitrogen supply of soils. One class known as the nitrogen-gathering bacteria live on the roots of legumes and, working through the stems and leaves of leguminous plants, take nitrogen out of the air and add it to the soil. Neither legumes nor the bacteria alone can take nitrogen out of the air, but when the two are working together they accomplish this interesting process. There are specific bacteria for each kind of legume, but practically all of them require the same soil conditions—non-acid soil and good drainage. When the bacteria are not present in the soil they can be introduced at the same time that the legume is planted.

Nitrifying bacteria convert nitrogen in the organic form to nitrates—a form that the roots of plants can absorb. Decaying vegetable matter contains its nitrogen in the organic form, and this nitrogen is of no use to succeeding crops till the nitrifying bacteria have converted it into an available form to be absorbed by the roots of plants. These bacteria require an open warm soil for their best

growth and work, and in a warm place like Hawaii they convert organic matter into nitrates very rapidly. Nitrates are soluble and may be leached out of the soil before a succeeding crop can absorb them.

De-nitrifying bacteria belong to the harmful class, because they reduce nitrates to nitrites and eventually gaseous nitrogen, which escapes into the air and is thus absolutely lost to the plants. In general, they are found under conditions that are opposite to those favorable for nitrifying bacteria. They do not need free oxygen and consequently are often abundant in poorly-drained soils. They are generally found in large numbers in fresh horse manure, and if fresh horse manure is applied together with a nitrate fertilizer it may result in the waste of expensive nitrogen fertilizer.

Some soils contain a type of bacteria that can fix nitrogen in the soil independently of legumes, but the amount of nitrogen they add is so small that they are only of minor importance. Bacteria that are responsible for many plant diseases are also found in the soil, but this introduces a big subject which should be treated as a separate topic.

After-War Sugar Prices*

By Romanzo Adams.

Under modern conditions of production and commerce a great war is sure to create profound disturbances in business relations. Sources of supply are cut off. New demands appear or, maybe, old demands are suddenly destroyed. Some sorts of production need to be speeded up, others need to be reduced, and still others must be reassured and made steady. Prices, if left to the free play of competition, are characterized by an extreme degree of fluctuation, and the fluctuations may be erratic—not corresponding to the fundamental conditions of supply and demand, but to the state of mind of the people, which may be optimistic one week, panicky the next, and ill-informed all the time. Some of the facts essential to the exercise of sound judgment are pretty sure to be concealed in war time. The extreme fluctuations in price do not guide production in the right way just because they are erratic. For example, copper production should have been put on a capacity basis in September, 1914, but prices were reduced and half the men in copper mines were laid off.

For this reason the governments of nations at war commonly undertake to regulate the prices of certain commodities by legal procedure and to control production of some means other than competitive prices. The need for such regulation and control continues after the war until considerable progress toward economic reconstruction has been made. The return of an industry from governmently controlled prices to a state of competitive control is more difficult than

* From a lecture given at the Short Course for Plantation Men, University of Hawaii, October, 1920.

the opposite procedure and calls for a profound understanding of business conditions.

The war control of sugar prices was pretty successful. Consumers were able to secure a fair supply at reasonable prices—prices high enough to encourage a steady increase in production in nearly all regions outside of Europe. These were the proper ends to be achieved. The return of price control to the forces of competition was not well timed or skilfully performed, and herein lies the secret of the erratic behavior of sugar in 1920.

A year ago, while we were still too near to the war and its immediate consequences to permit of an accurate estimate of world demand, sugar was turned over to the forces of competition except for some ineffective-for-good and unwisely used power in the hands of the Attorney General. It was known that there was a poor crop in Louisiana and that beet sugar production was below that of the preceding year. There was an exaggeration of Cuba's decrease in production. It was known that Europe's production was far below normal. Prohibition was expected to result in a marked increase in the use of sugar for soft drinks and candy in the United States. All these facts and supposed facts supported a forecast of high prices. The inflation of money and bank credit which occurred during the fall and early winter months was an influence in the same direction. Europe's early buying in Cuba was a factor. Added to all these price-raising factors was the state of the public mind. We had witnessed rising prices for so long a time that rising prices seemed natural. Factors tending toward low prices received scant consideration. Far too little weight was given to the reduction of Europe's demand because of lack of purchasing power. Little or no allowance was made for the Federal Reserve Board's announced deflation policy. While the mind of the business public was in this mood the Attorney General approved of seventeen cents for Louisiana sugar, apparently to save the planters from loss on account of a partial crop failure. Then canners and other sugar users became nervous and bought heavily to be sure of supplies. Refiners and jobbers usually buy heavily on a rising market, and so do many retailers. Of course, there were some irregular speculators. And while prices were at the top the writers in sugar trade journals were telling us that the prices were justified by fundamental conditions. The trouble arose from the fact that nobody knew the essential conditions. The competitive machinery had been out of use too long a time, and it failed to reflect fundamental conditions. At this distance it appears that there was little or no real sugar shortage so far as the United States was concerned. The Department of Agriculture has estimated recently that when prices were about at their highest there was an excess of sugar above the usual stock at that date of about thirteen pounds per capita—about one-seventh of a year's supply. The high price of sugar was due mainly to a series of mistakes and miscalculations.

One of the sources of miscalculation is worthy of a little further attention. There is no well-organized sugar market for speculation like there is for wheat and for cotton. Speculative buying of wheat is distinguished from millers' demand. What the speculator buys will come back into the market after awhile. What the miller buys is out for good. Now, since sugar had no regular speculator's market, most of the speculation being in the hands of refiners, jobbers,

grocers, and irregular speculators whose operations were not in the open, the speculator's demand was supposed to be a consumer's demand. We were regaled with accounts of the remarkable increase in sugar consumption when the sugar was only going into temporary hiding to appear later to help drive the prices down. An open market for sugar speculation would have prevented this mistake.

As long as prices are subject to the erratic after-war influences one can not forecast the future with a high degree of confidence. Who, a year ago, would have predicted for sugar or for coal the price fluctuations of 1920? Still, we need not give up altogether. Now that coal and sugar have had their fling, perhaps they will settle down to a more steady, and so a more predictable performance.

Apparently sugar prices for 1921 will be low—low in comparison with other commodity prices, low in comparison with the expenses of producing the crop. Much old crop sugar is still on hand. Beet sugar production in the United States is estimated at about forty per cent above last year's crop, and that of Europe is expected to show a thirty per cent increase. The acreage in cane has been increased in many regions, especially in districts where it has not been produced on a very large scale. Crop prospects seem to be fair. Probably Europe's increased production will be matched by her growing purchasing power. America will be able to secure abundant supplies at low prices.

If a moderate reduction in the price of sugar would stimulate consumption notably we might anticipate a marked increase in the American demand. But such is not the case. Sugar consumption is largely a matter of habit in America and is not much affected by considerations of economy. Barring unexpected deficiencies in production, this means lower prices.

There will be need for the speculator to carry over some of the 1920-21 crop to the next year. But speculators will not repeat the mistake of 1920. An opposite mistake is more probable. Refiners, jobbers, speculators, merchants, and housewives will carry low stocks in anticipation of still lower prices, and this will help to reduce the price.

If the above analysis for 1920-21 is correct there will be a diminished production in the following year and a consequent increase of price. In this readjustment of supply the beet sugar grower will take a more active part than the producer of cane. Good beetroot land is good land for corn, wheat, alfalfa, or other crops. Beet growing is carried on in connection with mixed farming, and little specialized equipment is needed, so that if the farmers are not satisfied with beet prices they turn easily to other crops.

In case the world achieves a condition of stable peace we may expect a gradual reduction of price fluctuations, and in two or three years the more permanent price influences will take control of the situation.

Report of the Committee on Milling.*

By Robt. E. Hughes.

As chairman of the Committee on Milling, I respectfully submit the following report:

I addressed letters and enclosed a list of questions to thirty mill engineers and received but six replies, which are incorporated in this report.

Since our last convention, held here in Honolulu in 1917, the developments and improvements in milling machinery have been forging ahead at a good rate, and so the increase in extraction, decrease in per cent moisture in the final bagasse, and general increase in efficiency, of all that has to do with the manufacture of sugar in the Islands is clearly shown by the records established in the milling plants.

Changes and improvements have been made at many stations throughout the mills.

The steel cane conveyor slat has proven beyond a doubt its superiority over all others by its continued good work wherever installed. Other improvements at the carriers, are the replacement with chain of the steel roller type, and the deepening of the carrier pits at the unloading stations.

Mr. Geo. Duncan, of Olaa Sugar Co., reports the following on Carriers:

"The only improvement made to the cane carrier is the substitution of steel slats for the wooden ones. The carrier is far cleaner underneath, and the stops to change broken slats are practically eliminated."

Mr. Geo. Crook, of Pioneer Mill Co., has the following to report on Carriers:

"We installed the Link Belt conveyor chain No. SS96, and corrugated slats last year. The chief advantage is less trouble with chain, slats, and bolts coming loose due to trash and cane cutting from the knives collecting in the links of the old class of chain and slat. There is less cleaning up to do in the cane carrier pit, and a saving of small cane in a season's run."

Mr. O. Olsen, of Lihue Mill, has the following to report on Carriers:

"The cane carrier was lowered last year, so that there is a drop of about eight feet from the cars."

The Puunene Mill reports the installation of the Link Belt No. SS96 bushed steel roller type chain, with the overlapping flat steel slat in Mill "B."

This chain is arranged to run on a steel rail, with guide bars of angle iron, so that the weight of cane on the carrier is not taken up by the chain; the chain being used merely to draw the load along.

* Presented at Eighteenth Annual Meeting of the Hawaiian Chemists' Association, held jointly with the Hawaiian Engineering Association, November, 1920.

Unloaders.

There is nothing new to report on unloading machinery, other than the gradual increase in installations of the Wicks type of unloader.

In the writer's opinion, all mills should be equipped with two unloading machines to a carrier, so that delays at this station will be positively eliminated.

The installation and upkeep costs of any of the three rake types of unloaders, namely, the Wicks, Bossee, and Ogg, are so low, that an extra machine will more than pay for itself in a season's run.

Revolving Knives.

At a recent visit with Mr. A. F. Ewart, of the Honolulu Iron Works, the writer was shown sketches of a new type of knife and shaft that is to be built and installed in the Waialua mill.

Mr. Ewart has kindly consented to include the prints in this report, and writes the following:

Improved Method of Attaching Knives in Revolving Cane Cutters.

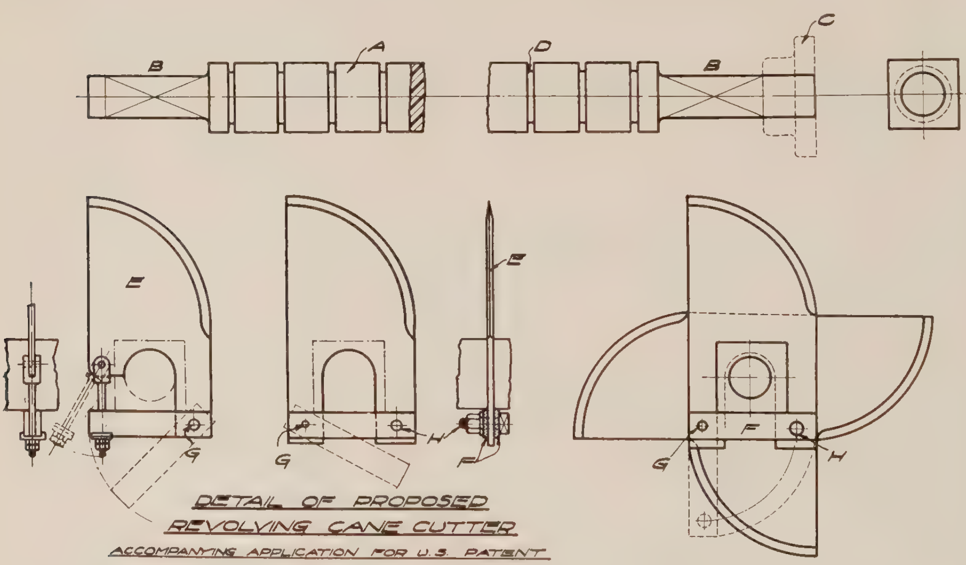


Fig. 1. Improved method of attaching knives in revolving cane cutters.

"In the process of extracting juice from sugar cane by crushing in roller mills, it is found advantageous to cut the cane just before it enters the first roller mill. The cutting is done by revolving knives.

"There are a number of different designs of revolving knives which all do more or less satisfactory work as far as the cutting of cane is concerned. All designs are alike liable to damage by pieces of metal (car links, chain, etc.) and stones passing along with the cane. It is desirable to replace any one of the knives without disturbing the adjacent ones or the system as a whole. The following description embodies this desirable feature of detachability of any one knife from the square shaft rotor without affecting any one of the other knives. (See Fig. 1.)

"A square shaft (a) preferably of steel is turned down at the ends (b) to be journaled in proper journal boxes, and one or both ends are extended beyond the journal to receive a pulley or coupling (c) to rotate it.

"At the desired spacing of the knives, grooves (d) are cut by lathe in a shaft of the proper width and depth to engage the butt ends of the knives. The knives (e) are made of flat steel with a tool steel cutting edge, and may be shaped as shown in accompanying sketch. The accurately-machined concave part of the knife snugly fits the cylindrical part of the shaft (a) at the bottom of the grooves (d).

"Of the two methods shown of mounting the knives on the shaft, the one having a swing bolt is preferred.

"The two plates (f) are hinged on a stout machined rivet (g). When placing a knife in the grooves these plates (f) hang in a vertical position, clearing the square of the shaft. After the knife rests at the bottom of the groove the two plates are brought up against the lower flat part of the square shaft. When using the swing bolt it engages the plates tightly against the bottom flat of the shaft, then the nut is set up pressing against the channel-like washer. The channel keeps the plates positively in position.

"In the other method, instead of the swing bolt a bolt (h) is used which passes through the plates (f) and the extended part of the knife as shown.

"It can readily be seen that to replace any one knife in a set only one swing bolt or a plain bolt needs to be manipulated, and the operation requires but a few minutes.

"The importance of this achievement will be appreciated not only from the very valuable point of saving time, but also, in the case of a broken knife, to put the rotor back in balance in a few minutes. In other designs the whole rotating system has to be removed and totally or partly dismantled in order to get at one knife. And the other point of value is that the fastening of the individual knives cannot throw the shaft out of true. This is important, as the shaft revolves at about 500 R.P.M. and any unbalancing or distortion of the shaft causes destruction to the bearings as well as other troubles."

Mr. Geo. Duncan, of Olaa Sugar Co., reports "that he is working on a scheme that he thinks will eliminate the breakage of knives, but at the time of writing it was not completed."

Mr. J. L. Renton, Ewa mill, reports a "great reduction in the amount of knife breakage, as much as 75% to 80%, by increasing the diameter of the hubs two inches, thereby decreasing the knife overhang by one inch. All knives are inclined right or left and sharpened to the center. The width of knife blade was increased from 4½" to 6"."

The writer wishes to say a word here in favor of the ball bearing and its use in connection with the revolving knife.

To give a schedule of the various machines where the ball bearing can be satisfactorily employed in the sugar factory would be difficult, but for the application of the ball bearing to the revolving knife, I feel quite safe in stating that it will be found more than satisfactory. In four years' experience with the ball bearing at the Puunene mills, 1,600,000 tons of cane have been ground without any delay due to these bearings. They are the S. K. F. type and are self-aligning, so that any temporary bending strain that might be thrown on the shaft while cutting through a heavily overloaded carrier is readily taken up within the bearing itself.

The bearing is enclosed in a dust-proof case, and lubricated by a medium oil,

which is circulated by a steam pump through the bearings and oiling system, the latter being a very simple home-made affair. It is true, the initial cost of this form of bearing is greater than that of any other type, but, then, when one figures the saving in grinding time, where any delay runs into money at a tremendous rate, to say nothing of the saving of power, the initial cost should not be such a deciding factor.

Without proper lubrication, and the right quantity of oil between two rubbing surfaces, there will be a friction loss which goes on day by day and which means an increase in fuel bills. This may not be noticed in some of the factories where they have an ample supply of bagasse; but where the bagasse supply is barely sufficient, and where fuel oil is used, any unnecessary friction will increase the cost of production.

Crushers.

The full mill size cast iron crusher is now generally recognized as the most efficient. Owing to its large diameter and full mill length the range of flexibility of grinding speeds at this station is greatly increased. Other advantages are an increase in extraction of 50% to 75% in some cases over the smaller-sized roller, a greater hydraulic pressure maintained, and the feed of a more even thickness entering the first mill rollers or shredders, as the case may be.

Mr. J. W. Kennedy, of Pepeekeo, reports the following on Crushers:

"I have been able to raise the extraction in the past two years, a little each year, due mostly to changing our crusher. We have a crusher about the same as used in the Puunene mills."

Mr. Olsen, of Lihue mill, reports:

"Putting in a 34"x 78" crusher this off-season, replacing a 26"x 72" Krajewski."

Mr. Geo. Crook, Pioneer Mill Co., submits the following:

"We installed the Krajewski type of crusher last year. The crusher is to be speeded up this season, to take care of a higher tonnage through the mill."

Mr. A. J. Horswill, of Makee Sugar Co., reports:

"We have added a cast iron Krajewski crusher, which is doing excellent work."

Puunene mill reports:

"The two sets of full-size cast iron Krajewski crushers installed in the Puunene mills in 1916 are still on the job, and have been doing good work. In the last five years a great deal of iron and steel, principally in the form of car pins and link, have passed through these crushers without any injurious results, owing to the great flexibility of the hydraulics."

Shredders.

The shredders at Puunene mills were equipped last off-season with the

S. K. F. type of thrust bearing, and though they gave some trouble at first, it was not due to any fault of the bearing, but to the fault of the setting, which was too close. A 1/32″ end clearance was allowed each bearing and no further trouble was experienced. As an experiment, one set of grate bars was removed during the last grinding season with no apparent change in the quality of the shredding. With the reduction of power, required to drive the shredder, in mind, the removal of as many grate bars as possible without interfering with the quality of the work, suggested itself. This season our shredders will be operated with a cutter bar, and two sets of grate bars only, thereby allowing more space for the shredded cane to escape as well.

Mr. Olsen, of Lihue mill, reports the following:

"I might mention here a few notes on the conveyor between the crusher and shredder (which is the usual chain and flight type) which might be of interest. We found that when the bottom plate of the conveyor was cut off square with the conveyor or parallel with the shredder it allowed the crushed cane to fall into the shredder all at once, causing quite a fluctuation on the load of the motor. At the same time the feed of the mill was very uneven, being heavy in the center and light on the ends.

"After experimenting with a Λ-shaped feed plate at the head end, we finally got a feed plate that allowed the cane to drop first at the ends and continued discharging until the center was reached, and we found an even feed on the first mill, allowing us to set the mill closer. At the same time the load on the motor was practically constant and the shredder ran a good deal quieter."

Intermediate Conveyors.

A number of new ideas in intermediate conveyors have been in successful operation the past two years. At Puunene soon after the shredders were per-

Fig. 2. Side view of carrier in use at Puunene mills.

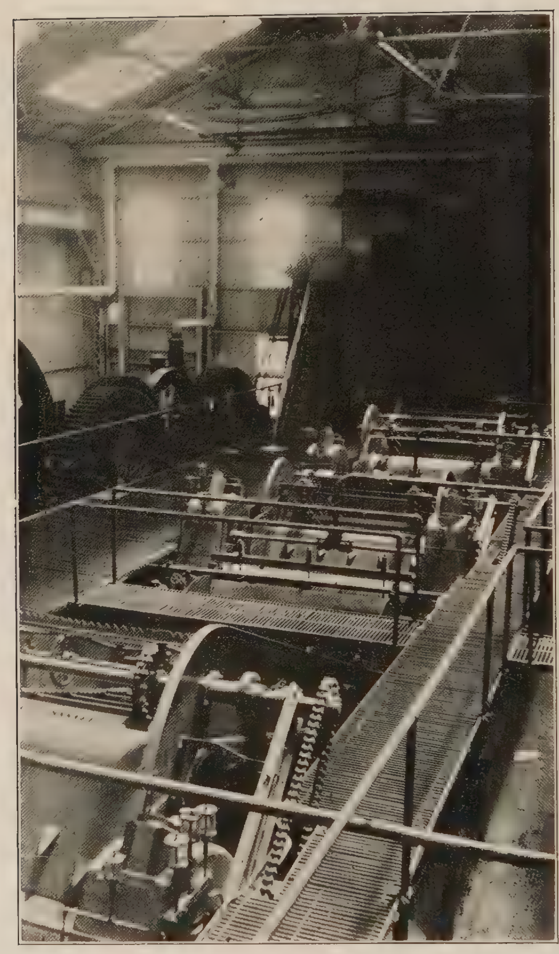


Fig. 3. View looking down on carrier arrangement at Puunene.

manently installed it became apparent that, eventually, we would have to provide some better type of conveyor between the mills, for the wide canvas belts then in use had served their usefulness. Owing to the nature of the material conveyed being changed, from the chip form to the very finely-divided shredded state, it was impossible to keep it from working out between the belt and side plates. In the off-season of 1918, the Ramsay type of drag conveyor was installed between the third and fourth mills, in "B" train, as a trial. The conveyor worked well until it became necessary to speed up to a greater tonnage. At 50 tons an hour, the cane would collect between the head shaft and angle iron slats; so that the chain would be slipped off the sprockets or broken. The experience had its benefits as well, however, and the following year two conveyors were installed between the first, second, and third mills, with the head shafts elevated to such a height that it is now impossible to choke the conveyor or interfere with its feeding the mill.

The following year this type of conveyor replaced the belt conveyors throughout the mills, and they have worked very satisfactorily.

We have Ramsay scrapers on all the mills and macerate partly through the scrapers, the remainder being applied after the blanket is divided by the conveyor slats. The floor plate of the conveyor is on such a steep angle, any excess maceration flows to the lower end rapidly and is again taken up by the oncoming blanket of cane.

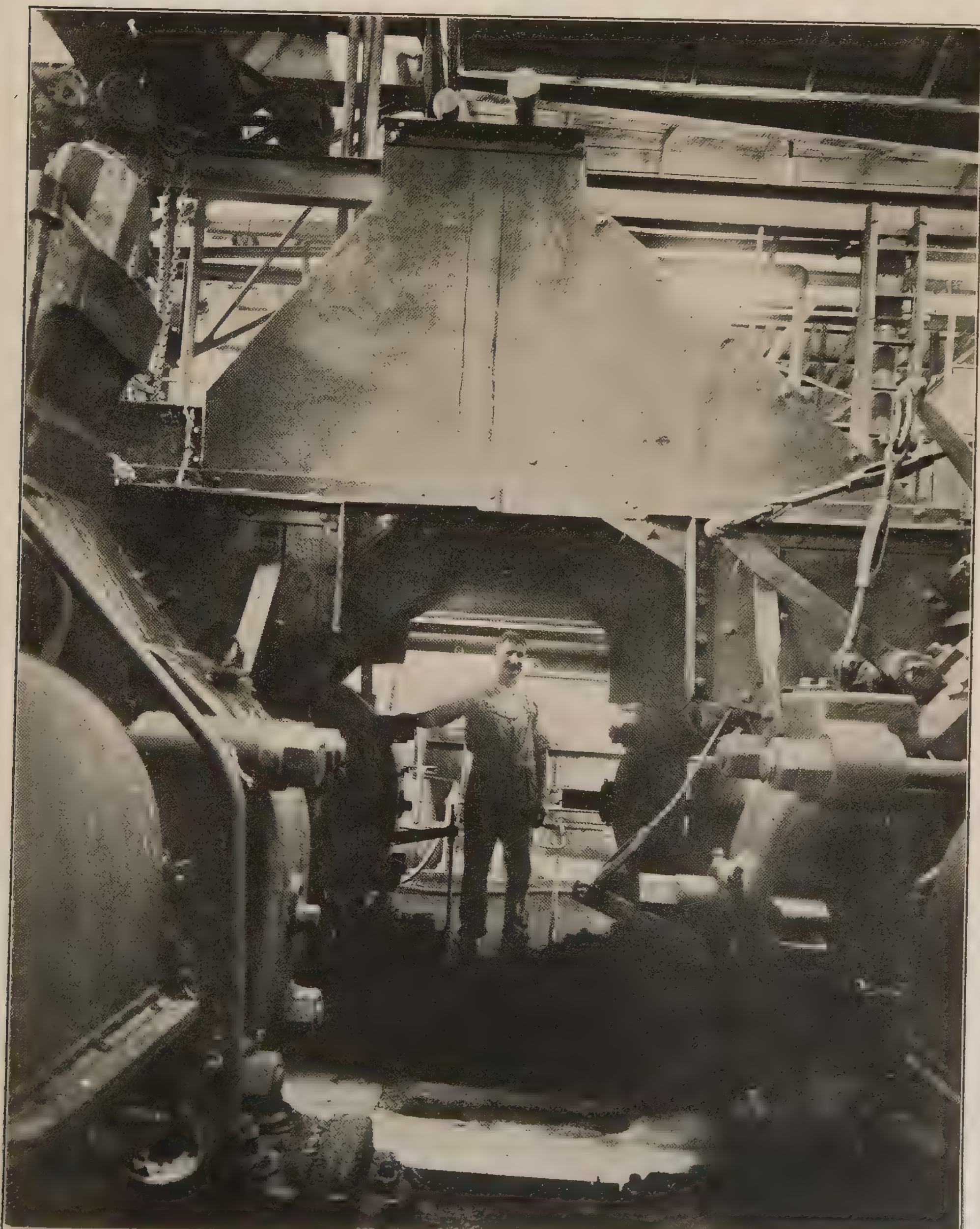


Fig. 4. Side view and clearance of Meinecke intermediate chute.

Fig. 5. Meinecke intermediate cane chute, showing cane sliding down chute into succeeding mills.

By the removal of a dozen small bolts, that are readily accessible, the whole conveyor can be removed in as many minutes.

Another advantage is a great deal of space under the conveyors, thereby admitting ample light and making it possible to walk all around any of the mills at any time, whether the mills are grinding or not.

Inspections can then be made at any time, and possibly serious breakdowns prevented, provided the warning be heeded and action taken in time.

Every drop of maceration applied must be taken up by the cane blanket passing along this conveyor, for there is no other possible avenue of escape. The same can be said of the shredded cane, thereby relieving some of the strain that would otherwise fall on the juice screens and cush-cush conveyor. The head end of the conveyor being high above the feed roller, the cane, on sliding down the chute into the mill, is subjected to a turnover, or rolling motion, on the way down, so that the over-saturated cane will be thoroughly mixed with the dry.

Figs. 2 and 3 show the conveyors in use at the Puunene mills.

The Meinecke Intermediate Chute.

During the grinding of the 1920 crop at Paia mill, a very interesting and successful experiment was carried on by Mr. J. Meinecke with an intermediate chute between the second, third, and fourth mills.

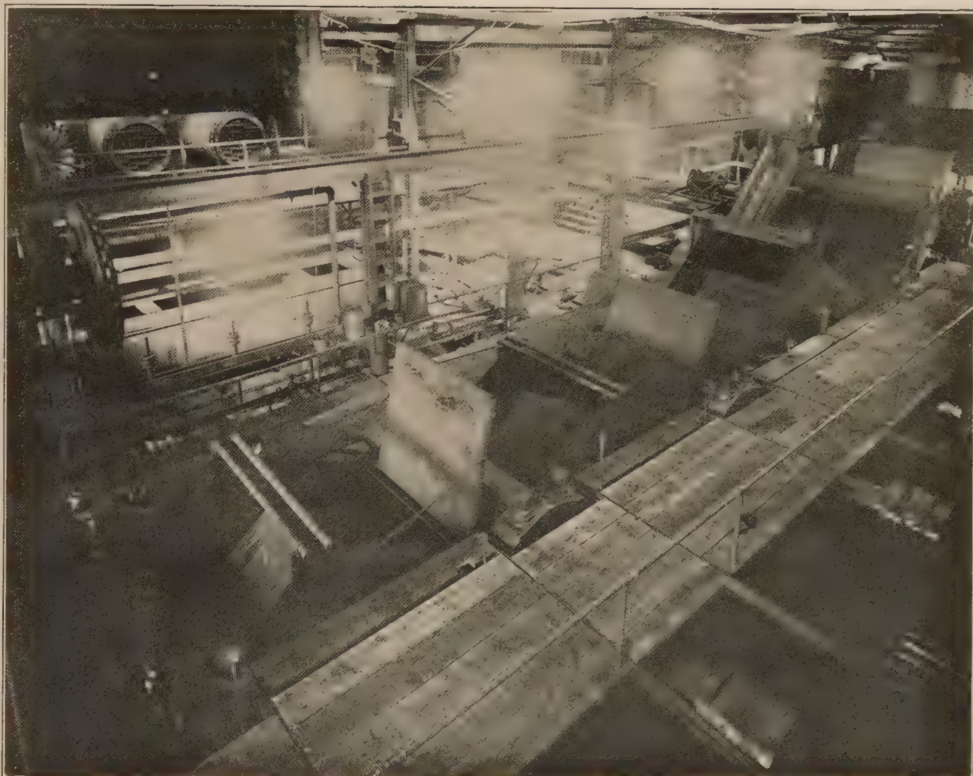


Fig. 6. Meinecke intermediate cane chute, showing top hinged cover opening for cleaning.

These chutes have replaced the old form of Link Belt and chain conveyor, with its many moving parts and its most unsanitary feature, that of the collection of fine particles of chopped cane between the slats; to say nothing of the delays due to this form of conveyor constantly breaking down.

The Link Belt and chain type of intermediate conveyor will soon be a thing of the past in Hawaiian mills, for it is being rapidly replaced with far more reliable types.

The Meinecke chute when properly built and installed should be free of breakdowns, as there are no moving parts to break. They are built of heavy steel plate throughout, and securely bolted to heavy angle iron flanged side plates, and at the same time, should any mill breakdown require the removal of the chute, it can be very quickly accomplished by the removal of a few bolts on each end, and lifting the chute up out of the way as one piece.

Referring to Fig. 4, one will get a general idea of the designs and arrangement of this chute. The crushed cane as it is discharged from the mill enters the space bounded by the bottom, sides, and top plates, and is pushed up the incline to a point almost directly above the man's head, and then drops by gravity into the feed of the succeeding mill.

The cane does not pack tightly on its way up the chute; in fact, before reaching the highest point of the chute the thick blanket of cane is clear of the top plate, from 4″ to 6″.

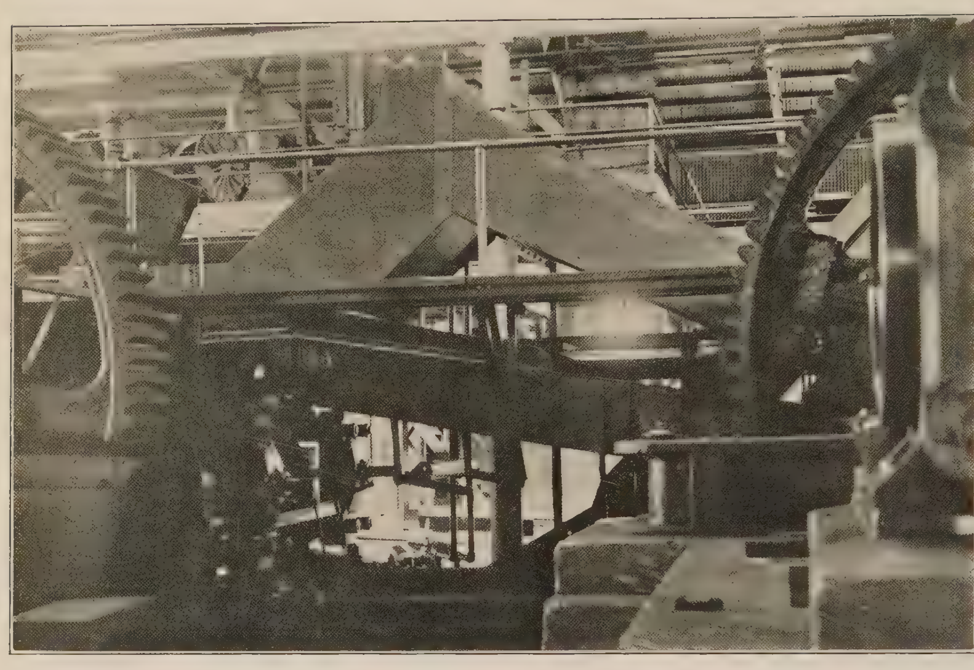


Fig. 7. Meinecke intermediate cane chute, side view, 21′ - 6″, centers of mills. To anyone not familiar with the mill, it might be well to explain that the cane enters this chute on the right-hand side.

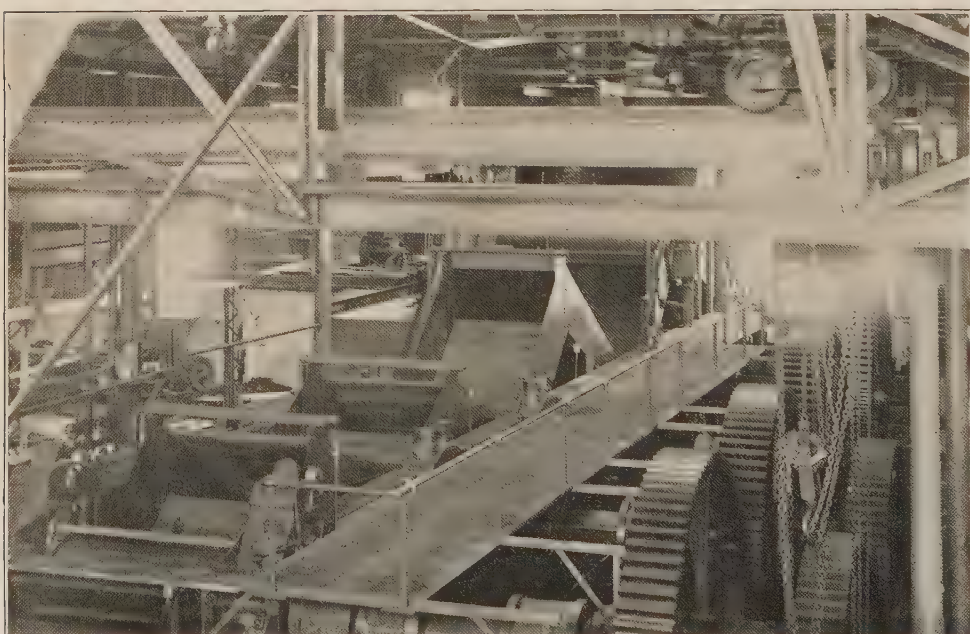


Fig. 8. Meinecke intermediate cane chute, showing cover plates in place.

The maceration is added at the highest point, as the blanket turns to descend into the next mill. Fig. 5 shows the cane sliding down the chute into the next mill.

The top or cover plate of the chute is made to hinge on one end. By the removal of three bolts on each side of the cover, it can be quickly lifted up and out of the way, thus making it quite an easy matter to remove the remaining cane that will be left in each chute after the mill shuts down for the week end.

Fig. 6 very plainly shows the cover plates fastened up and out of the way.

Mr. Meinecke has installed his cane chute between all of his mills at Paia for the 1921 crop, and in one case, between the sixth and seventh mills, the chute is fitted to a Ramsay macerating scraper, part of the maceration to be added as the cane passes through the scraper and the balance as it turns to slide down the chute into the mill. Fig. 7 is a side view of the chute between the first and second mills, and your attention is called to the much greater distance between mill centers in this installation. These mills are 21′ 6″ centers.

To any one not familiar with this mill, it might be well to explain that the cane enters this chute on the right-hand side.

Mr. Meinecke feels that this long chute can still be classed in the experimental stage, owing to the much greater distance that the cane must travel, and to the fact that this chute has not been tried out yet.

This experiment will be watched with much interest, and until its success has been assured the old conveyor directly below the chute will be left in place.

Fig. 9. Some of the discarded parts.

Juice Strainers.

In some mills the juice strainer is a constant source of trouble, and is responsible for considerable loss of time, due principally to poor design, such as insufficient capacity in screening area and in cush-cush conveyors.

The completely closed in strainer or the "fixed-for-the-season" type, is about

the poorest arrangement that could be placed in any modern mill of today, where they care anything at all about high extraction.

The chances for ferment, with its resulting loss of sugar, under the screens, and around the closed-in unwashable juice compartments of such an arrangement are very great in a season's run.

Juice screens should be made portable so that they can be removed at week-end stops, scrubbed on all sides with good stiff brushes, and washed off with a good strong force of water. One cannot be too vigilant in the care and attention around the juice strainers.

If there are any compartment tanks in use at all, they should be of generous proportions to allow for the fluctuations in juice levels which might be caused by an excessive amount of cush-cush at times taking up large quantities of juice, to insure a constant supply of return juice for maceration purposes, and to prevent flooding, with the consequent mixing of the juices.

It is of paramount importance that the tanks be supplied with some form of sight glass on one side so that the attendant can see the juice level at any time, and regulate the supply to the preceding mill accordingly.

Without some sort of an arrangement like the above, one would be working in the dark and be compelled to guess at the juice levels.

These sight glasses, being in plain view, tend to keep the man on the job as well.

The Peck Revolving Juice Strainer.

Something decidedly new and original in juice strainers has been designed by Mr. S. S. Peck.

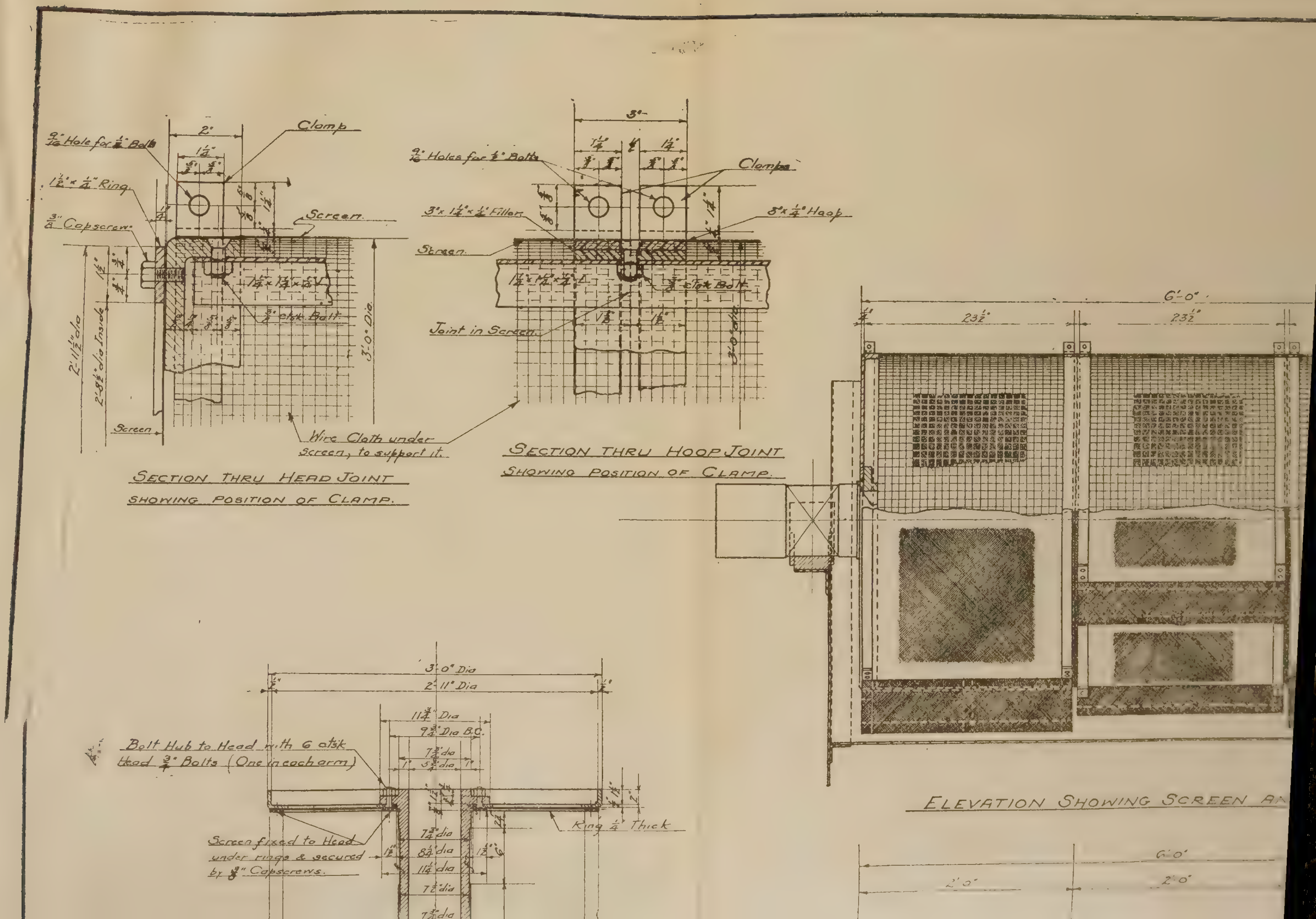
This strainer is of the revolving type and is arranged to be placed on the top of each mill.

Referring to insert, a description of the construction and operation can be more closely followed.

The strainer consists of two cast iron heads connected by angle iron frames which carry two wrought iron hoops on which the screen joints are made. The screens are put on in three sections and fastened up by clamped rings. These rings carry the paddle frames, which are also in three sections. In replacing a section of screen only the rings and paddles belonging to that section have to be disturbed. If two paddles in the width of a section are desired, extra paddles may be put on the rings.

The wire cloth is reinforced by a heavy screen of very coarse mesh, and the whole drum or strainer, which can be driven by a sprocket and chain from the top roller, revolves partly enclosed in a steel casing, the latter serving as a container for the juice and cush-cush. The juice and cush-cush are pumped together and piped to flow over the upper right-hand side of the screen, which is revolving in the same direction as the top roller.

Some of the juice will pass through the screen at the top, the remainder



Clamp
$\frac{9}{16}$" Hole for $\frac{1}{2}$" Bolts
$1\frac{1}{2}$" × $\frac{1}{4}$" Ring
$\frac{3}{8}$" Capscrew
Screen
$\frac{1}{2}$" ctsk Bolt
3'-0" Dia
2'-11$\frac{1}{2}$" dia
Screen
Wire Cloth under screen, to support it.
SECTION THRU HEAD JOINT
SHOWING POSITION OF CLAMP.
$\frac{9}{16}$" Holes for $\frac{1}{2}$" Bolts
Clamps
3" × $1\frac{1}{4}$" × $\frac{1}{4}$" Filler
3" × $\frac{1}{4}$" Hoop
Screen
Joint in Screen
$\frac{1}{2}$" ctsk Bolt
SECTION THRU HOOP JOINT
SHOWING POSITION OF CLAMP.
6'-0"
$23\frac{1}{2}$"
$23\frac{1}{2}$"
ELEVATION SHOWING SCREEN AN
3'-0" Dia
2'-11" Dia
$11\frac{3}{4}$" Dia
$9\frac{3}{4}$" Dia B.C.
Bolt Hub to Head with 6 ctsk Head $\frac{3}{4}$" Bolts (One in each arm)
Ring $\frac{1}{4}$" Thick
Screen fixed to Head under rings & secured by $\frac{3}{8}$" Capscrews.
$7\frac{3}{4}$" dia
$8\frac{1}{4}$" dia
$11\frac{1}{4}$" dia
6'-0"
2'-0"
2'-0"

soaking up through the bottom, where it is all quickly removed by means of the three suction pipes leading to a pump.

The cush-cush is pushed along by means of the screened paddles and is dropped into the mill.

Six small steam nozzles are arranged to spray the screen from the inside, removing any cush-cush that might otherwise be carried around.

There are no installations of this screen, but should it prove a success after trial, it will have a number of advantages over all others.

This screen is what one might call one of the sanitary type. It can be efficiently washed off a number of times a day and kept as clean as a whistle without much effort.

There are no slats dragging across the screening surface to plug up the perforations with cush-cush and eventually force it through into the juice.

The Fifteen-Roller Mill.

With a few notes and figures at hand relative to experiences with the fifteen-roller mill at Puunene, the writer feels that a brief review of the results, and a description of the arrangement, will be of interest to the members of this Association.

Due to the long continuous drought conditions through which our 1919 crop had to pass, returns fell far below the average for this plantation.

Harvesting the crop was slow compared with other years, our rate of grinding falling off to 96 tons an hour, so that the shutdowns for cane amounted to considerable of the total time.

It is usually the custom here to start the grinding season early, and with one mill only, until conditions become more favorable for harvesting. When the cane ripens faster, and over larger areas, the second mill is then put in operation. About the same tapering off at the end of the grinding season takes place, due to the planting requiring gangs of men that have to be supplied from the harvesting fields.

Taking these conditions into consideration, it is clearly seen that considerable quantities of extra fuel would be required to tide over these "under-capacity" times, as they might well be called. The boiling-house must be supplied with steam regardless of any other irregularities, and on nearing the end of the harvest the demands for steam from this end of the factory are doubled, due to the low grades that have to be worked off.

With the idea of eliminating these costly delays, the fifteen-roller mill was developed and operated during the past season, the idea being to grind as a fifteen-roller mill up to 85 tons an hour, thereby operating as a single unit over a longer period of time, with a saving of labor and fuel, the quality of the work to remain the same as when operating as a twelve-roller mill, grinding at 50 to 60 tons an hour.

To make it clear to all, I might mention here that the Puunene mills, consisting of two twelve-roller units, are arranged in parallel and are known as the "A" mill and "B" mill.

The "A" mill hydraulic accumulators, "B" mill engines and gearing occupy the space between the two sets of mills, they being about 60′ apart.

A steel conveyor 5′ wide and 60′ long was built and installed to fit in under the bagasse elevator of "A" mill on one end, and above the bagasse elevator of the "B" mill on the other end.

The cane, after leaving the fourth mill in "A" train, is conveyed to the fourth mill in "B" train, which we now call the fifth mill. This conveyor is driven by an electric motor controlled by the fifth mill engine-man with a switch near his engine. A shutter-like door is built into the "A" mill bagasse elevator, so that the cane can be diverted, either to the fire-room when operating as a twelve-roller, or to the fifth mill when operating as a fifteen. This change can be made in five minutes' time.

The cane after passing through the fifth mill is elevated into the fire-room in the usual manner.

Hot water maceration is added to the cane as it leaves the fourth mill, all the fifth mill juice being returned before the fourth mill by a centrifugal pump through a Ramsay scraper.

Approximately 26.25% of our crop was ground with the fifteen-roller mill, and some remarkable figures were obtained in tons of cane ground per hour, as well as extraction. The saving in fuel oil was difficult to determine, owing to a considerable outside fluctuating load that had to be taken care of by the turbo generators, though the saving was considerably over the oil consumption of the previous year, up to the time that it became necessary to operate as two twelve-roller mills.

The rate of grinding was increased from day to day until the record of 101.02 tons of cane an hour was established. This rate was maintained for one day only, though the two previous weeks were record runs of 92 and 93 tons per hour respectively.

The shredder walked away with the load, and the quality of the work was excellent. Apparently this load could have been increased 100% as far as the shredder was concerned.

No difficulties were experienced with the main engine, which is a 28″x 60″ Nordberg Corliss, with the long range valve gear, driving the first nine rollers at 57 R.P.M.. The fourth and fifth mill engines operated at 55 R.P.M.

The mill settings were not specially set to grind at this rate. The same setting was used for both rollers and returner bars, while grinding as twelve-roller mills at 60 tons per hour.

The following table is made up from the monthly reports, and is a clear record of the performance of this fifteen-roller mill that can be followed from month to month.

The final crop figures for the fifteen-roller mill are included at the bottom of this table:

	Nov. and Dec.	Jan.	Feb.	March	April	May	June
Hours grinding	556.00	349.00	109.75	13.00	140.75	71.25	40.00
Tons cane per hour....	79.74	89.92	67.47	71.55	63.05	57.29	55.29
Cane: Tons	44,335.950	31,380.385	7,405.065	930.100	8,874.515	4,082.020	2,211.750
Tons sucrose ...	6,462.89	4,718.68	1,145.98	155.48	1,463.66	689.77	362.75
% sucrose	14.58	15.04	15.48	16.72	16.49	16.90	16.40
% fiber	11.14	10.67	10.75	10.22	9.57	9.39	10.94
Bagasse: Tons	8,868.16	6,211.63	1,383.23	166.30	1,452.82	662.72	418.72
Tons sucrose..	68.29	60.00	8.87	1.06	8.32	4.05	1.78
% sucrose....	0.77	0.97	0.64	0.64	0.57	0.61	0.43
% moisture..	43.03	44.49	41.21	41.53	40.44	40.83	41.41
% fiber	55.70	53.92	57.53	57.18	58.47	57.83	57.77
Dilution % normal juice.	25.15	26.04	42.15	36.26	45.44	49.51	48.60
Extraction	98.94	98.73	99.23	99.32	99.43	99.31	99.51

FINAL CROP FIGURES FOR 15-ROLLER MILL.

Hours grinding	1,279.75
Tons cane per hour..............................	77.53
Cane: Tons	99.219.785
Tons sucrose	14,999.21
% sucrose	15.12
% fiber	10.74
Bagasse: Tons	19,163.58
Tons sucrose	152.37
% sucrose	0.80
% moisture	43.05
% fiber	55.60
Dilution % normal juice	30.14
Extraction	98.98

Total tons of cane ground by 15-roller mill.......	99,219.785
Highest grinding rate	101.02 tons per hour
Highest extraction over a period of 15.5 hours....	99.57
Fuel oil saved measured in dollars and cents......	$6,560.00

In the writer's opinion, the 15-roller mill equipped with a Searby shredder is about the finest arrangement of milling machinery that could be placed on a foundation bed.

The possible range of flexibility is enormous with such equipment, as well as being most efficient.

In conclusion I wish to thank the following gentlemen for data furnished of their respective mills, and Mr. A. F. Ewart for his contribution on knives: J. L. Renton, Geo. Crook, O. Olsen, Geo. Duncan, A. J. Horswill, J. W. Kennedy.

Report of the Committee on Indicating and Recording Instruments.*

By J. H. Pratt.

As this is an entirely new subject to be discussed by the Hawaiian Chemists' Association, I will endeavor to give a general view of the various types of apparatus that are obtainable and of the uses to which they may be put, rather than to attempt to tabulate a summary of present installations. The chief value of these instruments is that they not only show what is being done at any particular time, but also show what has happened when one's back is turned. The worth of these instruments is entirely dependent upon the use that is made of the information that they give.

The uses to which indicating and recording instruments may be put in a sugar factory are almost innumerable. The rapid rise in the cost of fuel during the past couple of years is rendering their services more important yearly. Fortunately, the amount of fuel needed in addition to the bagasse is, in most factories, small, but the demands on the fireroom for additional steam are increasing from year to year. Higher extraction, greater recovery, and larger-grained sugar are but synonyms for more steam. Each year the boilers are required to furnish power to drive additional machinery, to evaporate a higher dilution, to make a few more "cuts," or to run a distillery, paper plant, mule feed factory, or other profitable by-product.

For these reasons, the place where most mills start installing these instruments is in the fireroom, and it is possible to get an instrument for every need. Probably the most important of these is the CO_2 recorder, the importance of which is shown by the following table (U. S. Bureau of Mines):

Per Cent CO_2 ...	16	15	14	13	12	11	10	9	8	7	6	5	4	3
% Loss in Fuel..	10	12	13	14	15	16	18	20	23	26	30	35	45	60

There are many makes of CO_2 recorders, practically all being based upon the absorption of CO_2 by caustic potash (either as a solution or in cartridges) and the measurement of the per cent of gas removed. Some of these operate continuously and others intermittently with the intervals able to be regulated. Their principal difficulty is in collecting the sample of gas, due to the ashes, soot, etc., plugging up the pipes, gas washers, and filters. One company makes an automatic gas collector, so that should a CO_2 instrument prove too expensive an installation for a very small mill, samples may be collected automatically for any length of time from one to twenty-four hours (rate of collection can be altered easily) and analyzed with an ordinary Orsat apparatus. Another firm of makers tackles the problem from a different angle—they regard the air as the fuel. A steam flow meter records the steam production on the chart (in red ink), and an air meter records the flow of air (in blue). With perfect com-

* Presented at Eighteenth Annual Meeting of the Hawaiian Chemists' Association, held jointly with the Hawaiian Engineering Association, November, 1920.

bustion, the two curves follow the same line; when the red curve is highest there is a deficiency of air, etc. Specimen charts on which the CO_2 curve had been plotted by hand, show that the latter follows the other two curves extremely closely. An Orsat or other CO_2 apparatus may be used as a cheap substitute for a steam or water-flow meter. CO_2 is introduced into the flow of steam at a known rate, and after time for thorough mixing, a sample is drawn off and the per cent CO_2 determined, thus giving the amount of steam. This method is accurate to within 1½% to 1% when using only one pound of gas to a ton of steam. This method of Mr. E. G. Bailey is very easily installed, requiring only the drilling and tapping of two small (⅛″) holes in the steam line.

Draught gauges are made in several different types. The most common seems to be the liquid angle gauge. One make of these is very easily calibrated, as the scale is readily movable and may be set at the correct zero in the minimum time. A second type is the differential or U tube. Other kinds of draught gauges use German silver diaphrams or Bourdon tubes. Some makes of instruments indicate the draught in as many as five places in the passage of the gases with one instrument.

Steam and water meters are all based upon the "flow" principle and may be divided into two classes. The impact principle is used in the "pitot" tube, the "vortex", and the "metering bend"; the change in velocity type covers the "venturi" tube and the "orifice." The latter seems to be by far the most common type with the makers. The value of these instruments in measuring the boiler feed water, steam produced, and the steam used at various parts of the factory, such as the power-house, evaporators, pans, etc., is very obvious.

Probably the most common recording instruments in a sugar factory are pressure and vacuum gauges. The actuating mechanism is usually a single or double Bourdon tube, a helical tube, or a Sylphon metal diaphram. In some instruments the movement at high pressures is modified by an enclosing spring so that the vacuum scale is magnified; i. e., in a gauge registering vacuum and up to 250 pounds pressure, the vacuum would take up only 1/18 of the chart, while with a suppressed movement it would occupy ¼ of the chart. The places where these instruments could be installed would make a long list. The most prominent are: the steam and juice sides of the evaporators, pans, and juice heaters, on steam lines, engines, and pumps, water lines, fire line, etc.

Thermometers are in three general classes—those depending upon the expansion of an inert gas or air, the vapor of a volatile liquid, or of a liquid itself. The claims of the makers of these various types are very overlapping, but the favorites are nitrogen, alcohol, and mercury. In some, the movement of the helical or spiral tubes gives sufficient motion to the pen arm; in others it is multiplied by the use of rack and pinion, or links, levers, etc. By using a large bulb, the capillary tube connecting the bulb with the recording chart may be several thousand feet long, and by use of electrical apparatus, it may be even miles long. In many makes the action of heat on the capillary tube is compensated for by several ingenious devices. Some thermometers are equipped with electrical attachments which turn on a lamp or ring a bell when the temperature rises or falls to any desired limits. For condensers a special apparatus is made showing the temperature of the water entering and leaving, and the vacuum, all

on the one chart. Recorders are made with several pens on the same chart, and on some makes the arms can cross each other. One type of thermometer uses a nitrogen-filled tube, acting upon a simple U tube filled with mercury, one end being open to the atmosphere. The pen arm is attached to a float in the mercury.

Closely allied to thermometers are thermostats. There are several types of these. The electric ones are operated by the expansion of a medium (bi-metal bar) contained in the thermostat element or, for higher temperatures, by either a base-metal or platinum couple, similar to those used in pyrometers. Those using compressed air operate on a rubber diaphram or an all-metal bellows of the Sylphon type. Like the thermometers, these also may be equipped with an alarm light or bell. I believe that several factories in these Islands have been using this apparatus on their juice heaters for several years with much success.

Pyrometers measure the very small current generated by heating a pair of joined wires of different alloy. These thermo-couples are usually platinum and platinum-rhodium for high temperatures, and "base-metals" (such as nickel and chromium) for lower temperatures. The best instruments are compensating; i. e., variations in temperature of all but the fire end of the tube are corrected for. By the use of special switches the curves for different fire-ends may be plotted on the same chart. One firm of makers have over ten thousand of their instruments in use, and eight sugar refineries are on their list.

Time and motion recorders can be obtained with as many as twenty pens on the same chart. They can be operated by alternating or direct current or by dry-cell batteries. In most places in the sugar house their place could, I think, be well taken by other instruments, such as vacuum, pressure, or temperature gauges. They might, however, be very useful in keeping the time of grinding and the delays, and give also a good check on the centrifugal men, particularly when experimenting with different methods to hasten drying of low-grade. One testimonial states that they prove much more satisfactory for conducting experimental runs than a stop-watch, as the latter has a bad effect on the operatives. I believe that Waialua is using one of these time recorders to keep track of the delays at the milling plant. It has twelve pens, one for the total time shut down and the others for the main causes for stopping.

Liquid level gauges are used in several factories to keep a check on the filling and weighing of the mixed juice. Recording Brix instruments were tried out at Puunene several years ago, but did not prove satisfactory.

There are many and varied types of Tachometers, but their use in a sugar factory is rather limited. Some operate like an ordinary ball governor, others lift a column of mercury, others run a small electric generator, while others vibrate a series of tuning forks.

Automatic counters come in a variety of forms and prove very useful in counting the number of bags of sugar made, the revolutions made by engines, tanks of juice filled or weighed, etc.

As I previously stated, the value of these instruments is almost entirely dependent upon the use that is made of the information given by them. Unfortunately, very few of these instruments are equipped with any integrating devices,

so that planimeters are necessary. These are made by most of the instrument manufacturers and are comparatively inexpensive.

For the convenience of those contemplating the purchase of recording instruments, I append the following partial list of manufacturers. I am also turning over to the secretary of this Association catalogues of nine of these companies:

The Bristol Company, Waterbury, Conn.
The Brown Instrument Co., Philadelphia, Pa.
The Foxboro Company, Foxboro, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.
Taylor Instrument Co., Rochester, N. Y.
Bailey Meter Co., Cleveland, Ohio.
Precision Instrument Co., Detroit, Mich.
Uehling Instrument Co., New York, N. Y.
Powers Regulator Co., Chicago, Ill.
Johnson Service Co., Milwaukee, Wis.
Hoskins Mfg. Co., Detroit, Mich.
Sarco Company, New York, N. Y.

Report of the Committee on Electrification.*

By J. Lewis Renton.

With the steady increase in the application of electricity to the sugar mills in the Hawaiian Islands, the question of electrification is an important one to all mill engineers.

Standardization.

In the case of D. C. industrial drive, the following voltages have come into almost universal use:

Generator.	Motor.
125	115
250	230
575	550

The following A. C. voltages have come into such common use that they may be considered standard:

* Presented at the Eighteenth Annual Meeting of the Hawaiian Chemists' Association, held jointly with the Hawaiian Engineering Association, November, 1920.

Generator	Transformer	Motor
120	115	110
240	230	220
480	460	440
600	575	550
2,300	2,300	2,200
6,600	6,600	6,600
11,000	11,000	11,000
13,200	13,200	13,200

The usual preference is to use alternating rather than direct-current power, due to the ease of handling, the simplicity of apparatus and, as a rule, the lesser investment involved.

Practically all American-made alternating-current machines are now designed for 60-cycle operation.

The unquestionable superiority of the 3-phase over the single and 2-phase power circuits needs no argument for its adoption.

Leaving out direct-current apparatus, the selection of alternating-current power involves nothing but the selection of the proper voltage, and the tendency seems to be strongly inclined to 440 volts for mill use in the Hawaiian Islands. The voltage to be generated depends on whether the power is to be generated at the factory or at some distant plant, and what use is to be made of the power; therefore, each case would have to be taken up individually, transformers being used to obtain desired voltage for different conditions.

The fewer different voltages used in the different factories in the Islands, the better will be the service rendered by the supply houses here, as it will enable them to keep up a good stock of a few different machines in preference to a somewhat varied selection of many machines. The obvious advantage to be gained is prompt deliveries when necessary.

Wiring.

Cables in conduit or ducts make a more permanent and neater installation, and for that reason much of the new work now going on is of this nature. Its first cost is its chief drawback; besides, in small installations open wiring is preferred by some of the engineers because it is simple, easy to locate trouble, and easy to repair.

Iron conduit should not be employed on alternating current unless all conductors of the circuit are in the same conduit. The general practice is to use iron conduit up to about 2 inches in diameter. For larger sizes, fiber or tile conduit is much less expensive and is satisfactory.

The use of conduit in hot atmosphere, over 100° F., such as is encountered in parts of fire-room and boiling-house, is not recommended by some authorities, as there is apt to be "sweating" in the conduit, causing a breaking down of the insulation with resulting short circuits.

It goes without saying that all wiring and apparatus should conform with the regulations of the National Board of Fire Underwriters.

Electrification of Milling Plant (Rollers).

To compete with the steam engine as a prime mover for sugar-mill roller trains an electrical motor must be dependable, simple, and have a variable speed. Considerable success has been had with the slip-ring or wound-rotor induction motor, which has the good characteristics of the induction motor plus a good starting torque. Variations in speed are obtained by varying the external resistance, in series with the rotor winding, and the usual practice has been to use large grid type resistance.

One of the large electrical manufacturers has put out a "Liquid Type Controller" in place of the grid resistance for the rotor circuit.

The apparatus consists of a tank with an upper and lower compartment, with the electrodes of the rotor circuit suitably insulated and rigidly suspended in the upper compartment. The lower compartment of the tank is for cooling and storage of the electrolyte, which is a suitable mixture of sodium carbonate and water.

The speed of the motor is governed by the height of the electrolyte in the upper compartment, as the speed varies inversely with the resistance in the rotor circuit. A multiple shutter type of weir closes, or opens, the connection between the upper and lower compartments, the maximum resistance being obtained when all shutters are opened. A small motor-driven centrifugal pump circulates the electrolyte from the lower to the upper compartment, thus closing the shutters, and causing the height of liquid in the upper compartment to rise. The shutters are operated by a motor with provisions made for operating them manually if necessary. Horizontal plates fastened to top of electrodes practically short-circuit rotor windings when horizontal plates are covered. An interlocking switch prevents starting motor unless all resistance is in rotor circuit.

The advantages claimed are:

- Simple and durable.
- Uniform elimination of resistance; therefore uniform speed change.
- Any desirable speed; not step by step change of speed.
- No contacts broken; therefore no arcing.
- No danger of burning out resistance on prolonged operation at slow speed with high resistance in rotor circuit.

Useful Information.

Power Transmitted in Three-Phase Three-Wire Circuits.

P — Power in KW.
1 — Current per wire in amperes.
E — Potential between wires in volts.
Cos ϕ — Power factor.

$$P = \frac{3 \ E \ 1 \ \text{Cos} \ \phi}{1000}$$

Testing Single-Phase Watthour Meters.

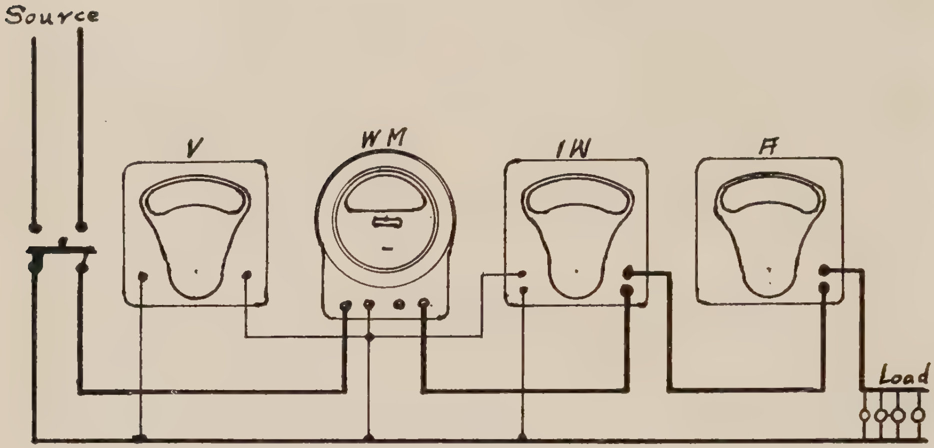


Fig. 1.

Fig. 1 shows a watthour meter connected for test with indicating instruments. The voltmeter and ammeter are not necessary unless it is desired to check the line voltage or to note the power-factor of the load.

The watts recorded by the meter, i. e., the rate at which the meter is recording, can be found by the formula

$$\frac{3600 \times K \times R}{S} = \text{watts.}$$

R — Number of revolutions.
S — Number of seconds required to make this number of revolutions.
K — Constant marked on the meter disk.
3600 — Number of seconds in an hour.

Take a sufficient number of revolutions so that the time of observation will be from 30 to 60 seconds. If materially less than 30 seconds, errors in the measurement of time are probable, and observations of a duration greater than 60 seconds are generally unnecessary.

A convenient method of testing a three-wire meter is to connect the current coils in series and test as a two-wire meter, using the constant marked on the disk.

To check the equality of the two current coils, the meter may be read with load first on one current coil alone, and then upon the other alone, using in this case a calibrating constant equal to the disk constant multiplied by two.

Example: Meter to be tested, 5-ampere, 110-volt, 60-cycle, where K, the constant marked on the disk, is .3.

Suppose the load shown by the indicating wattmeter is 540 watts and that the disk has been found to make 20 revolutions in 40 seconds.

Using the formula it is found that

$$\text{Meter watts} = \frac{3600 \times .3 \times 20}{40} = 540$$

Therefore, the meter is correct. If the disk had made 20 revolutions in 40.8 seconds, the meter watts would be found to be 529.4 and the accuracy:

$$\frac{529.4}{540} = 0.98$$

That is, the percentage accuracy is 98, or the meter is 2% slow.

Method of Testing with Test Meter.

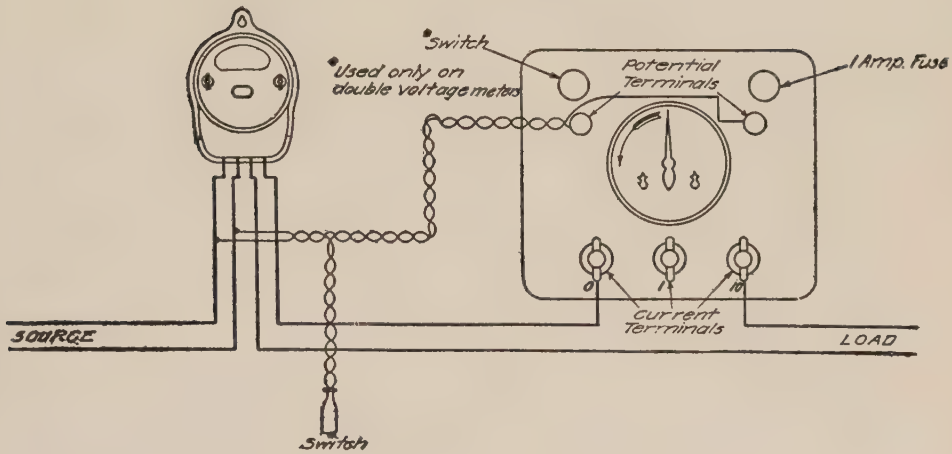


Fig. 2.

The portable test meter provides a means for testing quickly, yet accurately, and independently of load variations. Fig. 2 shows the method of connecting a two-wire watthour meter when testing with a single-phase portable test meter.

Set the meter in a level position free from vibration. Connect the proper current terminals of the test meter, between the load and the meter undergoing test, with connections as shown on the instruction card accompanying the test meter.

Connect the potential circuit to the service switch by means of leads provided for that purpose. Connect the potential circuit of the test meter ahead of the meter under test and the current circuit of the test meter after the meter under test so that neither shall record the losses in the potential circuit of the other and thereby introduce appreciable error at light load. Potential leads with pendant snap switch are provided with each test meter. When properly connected, the large pointer will rotate counter-clockwise. To change the direction of rotation, reverse either the current or the potential leads. The test meter is started and stopped by closing and opening the snap switch.

Stop the test meter register by opening the pendant snap switch and note the reading of the pointers. Start the test meter simultaneously with the counting of the disk revolutions of the meter under test and stop it by the snap switch after the required number of revolutions has been taken and the position of the pointers again noted.

The number of revolutions noted during the test on the dial of the test meter multiplied by the proper constant (depending on the current winding used) gives the watthours recorded by the test meter. The number of revolutions of the disk of the meter being tested, multiplied by its constant (marked on the disk), equals the watthours recorded by the meter under test. Any overrunning of the test meter after the switch has been opened is due to the momentum of the moving element and in no way affects the accuracy of the reading. The over-running at the end of the test is compensated for by the slight lag in starting.

The ratio of the watthours recorded by the meter under test to the watthours recorded by the test meter equals the accuracy of the meter. Take a sufficient number of revolutions to make negligible any errors of observation in reading the pointer indications and to minimize any error due to not starting or stopping the test meter simultaneously with the counting of the disk revolutions of the service meter.

$$\text{Accuracy} = \frac{r \times k}{R \times K} = \frac{\text{watthours of meter under test}}{\text{watthours of test meter}}$$

r — Revolutions of meter under test.
k — Disk constant of meter under test.
R — Revolutions of large pointer of test meter.
K — Constant of test meter.

Example, Case 1. Meter to be tested, 10-ampere, 110-volt, 60-cycle induction meter, when k, the constant marked on the disk, is .6. Assuming that we are testing at approximately full load, we will use the 10-ampere current winding on the test meter which has a constant K equal to .6 as noted on the instruction card in the test meter cover. Suppose the test meter made 25 revolutions while the meter under test made 25, the equation

$$\frac{r \times k}{R \times K} = \text{accuracy}$$

becomes $\frac{25 \times .6}{25 \times .6} = 1.00$ or 100 per cent accuracy, which indicates that the meter is correct.

Suppose, however, that the test meter registers 24 revolutions while the meter under test made 25, the equation would be $\frac{25 \times .6}{24 \times .6} = 1.041$, indicating that the meter under test is 4.0 per cent fast.

Again suppose the test meter registered 26 revolutions while the meter under test made 25, the equation would be $\frac{25 \times .6}{26 \times .6} = 0.962$, indicating that the meter under test is 3.8 per cent slow.

When testing a meter operating from instrument transformers the constant of such a meter must be divided by the product of the ratios of the transformers.

NORMAL RATED AMPERES, THREE-PHASE INDUCTION MOTORS.

H. P.	Speed	110 v.	220 v.	440 v.	550 v.	2200 v.
1	1800	7.0	3.5	1.7	1.4	
1	1200	6.9	3.4	1.7	1.4	
1	900	8.1	4.0	2.0	1.6	
2	1800	11.3	5.7	2.8	2.3	
2	1200	11.8	5.9	2.9	2.4	
2	900	12.3	6.1	3.1	2.5	
3	1800	15.9	7.9	4.0	3.2	
3	1200	17.2	8.6	4.3	3.4	
3	900	18.2	9.1	4.5	3.6	
5	1800	25.5	12.7	6.4	5.1	
5	1200	27.0	13.5	6.8	5.4	
5	900	28.7	14.3	7.2	5.7	
7½	1800	37.0	18.5	9.2	7.4	
7½	1200	38.7	19.3	9.7	7.7	
7½	900	41.6	20.8	10.4	8.3	
10	1800	48.8	24.4	12.2	9.8	
10	1200	50.4	25.2	12.6	10.1	
10	900	56.2	28.1	14.0	11.2	
15	1800	75.0	37.5	18.7	15.0	3.7
15	1200	75.6	37.8	18.9	15.1	4.0
15	900	81.0	40.0	20.0	16.2	
20	1200	101	50.0	25.0	20.2	5.2
20	900	104	52.0	26.1	20.9	5.8
20	720	120	60.0	30.0	24.0	5.8
25	1200	....	62.4	31.2	25.0	6.1
25	900	....	66.5	33.2	26.6	7.5
25	720	....	66.0	33.0	26.4	7.2
35	1200	....	84.5	42.3	33.8	8.9
35	900	....	89.4	47.7	35.8	9.1
35	720	....	92.5	46.2	37.0	9.8
50	900	....	123	62.0	49.4	12.8
50	720	....	128	64.0	51.0	13.7
50	514	....	138	69.0	55.0	14.2
75	900	....	184	92.0	74.0	19.0
75	720	....	190	95.0	76.0	19.3
75	514	....	206	103	82.0	20.6
100	720	....	246	123	98.0	23.2
100	600	....	260	130	104	25.5
100	450	....	270	135	108	27.0
150	720	....	....	181	145	31.8
150	600	....	....	185	148	37.4
150	450	....	....	200	161	45.0
200	600	....	....	241	193	50
200	514	....	....	252	202	53
200	400	....	....	268	214	53

STANDARD INSULATED CABLES FOR INSTALLATION WORK.

Ampere Range From	Ampere Range To	Amps. Normal Rated Load	No. Cables	Size	Temp. Rise, ° C. Full Load	Temp. Rise, ° C. 50% Overload
1	9	8	1	No. 12 B & S Solid..........	10	20
10	14	12	1	No. 10 " "	14	28
15	24	20	1	No. 8 " "	10	20
25	36	30	1	No. 6 " "	9	18
37	56	45	1	No. 4 " Stranded	10	20
57	84	70	1	No. 2 " "	10	20
85	124	100	1	No. 0 " "	10	20
125	169	150	1	No. 000 " "	12	24
170	184	175	1	No. 0000 " "	12	24
185	224	200	1	250,000 C M	12	24
225	264	250	1	300,000 "	14	28
265	324	300	1	400,000 "	13	26
325	374	350	1	500,000 "	12	24
375	499	450	1	750,000 "	12	24
500	649	600	1	1,000,000 "	13	26
650	749	700	1	1,250,000 "	12	24
750	899	800	1	1,500,000 "	13	26
900	1099	1000	1	2,000,000 "	12	24
1100	1299	1200	2	1,000,000 "	13	26
1300	1599	1500	2	1,250,000 "	14	28
1600	2249	2000	2	2,000,000 "	12	24
2250	2649	2500	3	1,500,000 "	14	28
2650	3349	3000	3	2,000,000 "	12	24
3350	3599	3500	4	1,500,000 "	15	30
3600	4399	4000	4	2,000,000 "	12	24
4400	5599	5000	5	2,000,000 "	12	24
5600	6600	6000	6	2,000,000 "	12	24

NOTE:—Temperatures in first column are based on continuous operation at normal rated load; second column on 2 hours' operation at 50% overload. For 50% overload continuously, temperature will be about 11° higher than last column. Maximum raise should not exceed 30° C. Paper insulation—increase all temperatures 10%.

CALCULATION OF SAG AND TENSION.

$$S = \frac{(L)^2W}{8T} \qquad T = \frac{(L)^2W}{8S}$$

Where T = Wire tension in pounds.
L = Length of span in feet.
W = Weight of one foot of conductor and insulation.
S = Sag or deflection in feet.

ANNEALED WEATHERPROOF WIRE.

B & S Gauge......	10	8	6	4	2	1	0	00	000	0000
Breaking Stress....	283	440	700	1114	1772	2234	2818	3553	4480	5650

HARD DRAWN BARE WIRE.

B & S Gauge......	10	8	6	4	2	1	0	00	000	0000
Breaking Stress.....	500	778	1237	1967	3127	3943	4973	6271	7907	9971

NOTE:—In calculating sag, working stress should be taken as one-quarter breaking stress given in table.

SIZES OF WIRES AND CABLES FOR THREE-PHASE INDUCTION MOTORS.

H. P.	Volts				
	110	220	440	550	2200
1	10 B. & S.	10 B. & S.	10 B. & S.	10 B. & S.	
2	10 "	10 "	10 "	10 "	
3	8 "	10 "	10 "	10 "	
5	6 "	10 "	10 "	10 "	
7.5	4 "	8 "	10 "	10 "	
10	4 "	6 "	10 "	10 "	
15	2 "	4 "	8 "	8 "	
20	0 "	2 "	6 "	8 "	
25	....	2 "	6 "	6 "	10 B. & S.
35	....	0 "	4 "	6 "	10 "
50	....	000 "	2 "	4 "	8 "
75	....	250,000 C. M.	0 "	2 "	8 "
100	....	300,000 "	000 "	0 "	6 "
150	....	....	250,000 C. M.	000 "	4 "
200	....	....	300,000 "	250,000 C. M.	4 "

The October number of this year of the *Hawaiian Planters' Record* contains a very interesting article on the actual application of electrification.

The Chairman of the Committee on Electrification wishes to thank Mr. E. B. Gibson for his valuable assistance.

Annual Synopsis of Mill Data, 1920.

By W. R. McAllep.

For the first time the Annual Synopsis contains data from all factories in the Association; a total of forty-two. As has been the tendency from year to year, more nearly complete data have been received from a larger number of factories, particularly from the smaller ones. Unfortunately, however, a greater number of factories than usual have been late in finishing their grinding season and have had to report on the portion of the crop ground prior to September 30, so, though returns have been received from all the factories the figures do not represent quite all of the 1920 crop.

In compiling the three large tables the arrangement similar to that of the two previous years has been followed; that is, the factories are listed in the order of the size of their crop, taking as a basis the average of the preceding five years. The first of these tables is a compilation of the results secured by the individual factories, true averages of these results and for comparison averages for the preceding nine seasons.

Six of the factories on the island of Oahu have been affected by a strike of the plantation laborers. The work in these factories has suffered on account of inexperienced labor and overtaxed boiling house capacity due to low purity juices from cane that should have been harvested earlier. These factories grind a sufficient portion of the total crop so that their results materially affect the averages. In order that the work of the factories that were not handicapped by these conditions may be compared with that of last year, a second set of averages for the years 1919 and 1920 has been calculated, with the data from the factories affected by the strike omitted. These averages appear in Table 9. The second of the large tables is a tabulation of knife, mill and returner bar settings, pressures, roller speeds, etc. The third shows the surface and juice grooving used this season.

Varieties of Cane.

Table 1 shows the varieties of cane ground by the different factories. This table has been rearranged. Varieties making up one per cent or more of the total crop are listed in separate columns and these columns arranged in the order of the tonnage ground.

Comparing the principal varieties with last year, D 1135, H 109, the Tip canes and Striped Mexican show a gain. Caledonia and Lahaina show a loss. 88.5% of the total tonnage is made up of the four principal varieties: Yellow Caledonia, Lahaina, D 1135 and H 109. Yellow Caledonia was ground in appreciable amounts at all but four of the factories. D 1135 is the next most widely distributed, all but 12 factories reporting this variety. Over half of the column headed "Other Varieties" consists of the following, each of which made up one per cent or more of the tonnage ground at one of the mills.

TABLE NO. 1.
VARIETIES OF CANE.

	Yellow Caledonia	Lahaina	D 1135	H 109	Striped Tip & Yellow Tip	Striped Mexican	D 117	Other Varieties
H. C. & S. Co.	..	65	19	16	..	..	..	..
Oahu	4	70	11	8	..	..	..	7
Ewa	14	10	..	72	..	..	..	4
Maui Agr.	6	58	22	6	..	4	..	4
Pioneer	1	63	2	..	..	33	..	1
Waialua	9	37	25	10	..	..	3	16
Haw. Sug.	1	49	29	11	..	..	..	10
Olaa	86	..	14	..	..	..	..	..
Honolulu	44	40	4	11	..	..	..	1
Onomea	82	..	..	..	18	..	..	..
Hakalau	100	..	..	..	..	..	..	..
Kekaha	..	85	14	..	..	..	..	1
McBryde	51	..	30	19	..	..	..	..
Hilo	94	..	5	..	..	..	..	1
Wailuku	3	21	15	19	..	32	..	10
Haw. Agr.	56	..	6	..	..	..	..	38 *
Lihue	100	..	..	..	..	..	..	..
Lihue, Han	99	..	1	..	..	..	..	..
Waiakea	100	..	..	..	..	..	..	..
Makee	96	..	..	..	..	..	..	4
Honokaa	55	..	16	1	28	..	..	..
Laupahoehoe	45	..	10	..	31	..	14	..
Pepeekeo	98	..	1	..	1	..	..	..
Kahuku	47	43	8	2	..	..	..	..
Koloa	94	4	2	..	..	..	..	..
Hamakua	31	..	12	..	15	..	40	2
Hawi	46	..	11	2	40	..	..	1
Paauhau	85	..	10	1	3	..	..	1
Honomu	99	..	..	..	..	..	1	..
Hutchinson	42	..	1	..	5	..	..	52 †
Kaeleku	100	..	..	..	..	..	..	..
Kohala	35	..	30	..	35	..	..	..
Kaiwiki	71	..	7	..	12	..	10	..
Waianae	3	60	..	34	..	..	..	3
Kilauea	99	..	1	..	..	..	..	..
Waimanalo	100	..	..	..	..	..	..	..
Niulii	96	..	1	..	3	..	..	..
Halawa	62	..	10	..	28	..	..	..
Union Mill	52	..	2	..	45	..	..	1
Olowalu	..	100	..	..	..	..	..	..
Waimea	..	78	2	20	..	..	..	..
Kipahulu	100	..	..	..	..	..	..	..
True Average 1920	42.7	26.7	10.0	9.1	3.5	2.5	1.0	4.5
" " 1919	46.4	29.1	7.2	6.8	2.9	1.8	1.1	4.7
" " 1918	42.9	37.9	7.5	4.0	2.0	0.6	0.8	4.3

* Rose Bamboo 7%, White and Yellow Bamboo 18%
† Rose Bamboo.

TABLE NO. 2.

COMPOSITION OF CANE BY ISLANDS.

	Hawaii	Maui	Oahu	Kauai	Whole Group
1911					
Polarization	12.91	15.45	14.45	13.51	13.99
Percent Fiber	13.27	11.79	12.92	13.26	12.85
Purity 1st Mill Juice	88.15	91.57	88.20	87.46	88.83
1912					
Polarization	13.30	16.00	14.38	14.06	14.34
Percent Fiber	13.53	11.53	12.62	12.59	12.67
Purity 1st Mill Juice	88.40	91.13	88.46	88.30	89.04
1913					
Polarization	13.22	15.56	14.21	13.70	14.05
Percent Fiber	13.74	11.73	12.75	12.50	12.85
Purity 1st Mill Juice	88.47	91.11	88.20	88.12	89.02
1914					
Polarization	12.75	15.16	14.23	13.62	13.78
Percent Fiber	13.62	11.59	12.44	12.75	12.74
Purity 1st Mill Juice	88.22	91.02	88.11	87.51	88.71
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Mill Juice	87.86	90.48	87.27	86.99	88.24
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Mill Juice	87.56	89.41	87.15	86.26	87.70
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Mill Juice	88.11	90.69	86.86	86.70	88.02
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Mill Juice	87.27	88.62	86.93	85.88	87.18
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Percent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Mill Juice	87.54	88.81	87.00	85.82	87.34
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Percent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Mill Juice	87.87	88.94	85.40	86.52	87.24

Variety.	Per Cent of the Total Crop.
H 146	0.81
Rose Bamboo	0.78
Yellow Bamboo	0.45
White Bamboo	0.17
H 20	0.15
H 227	0.04
	2.40

Composition of Cane by Islands.

This is shown in Table 2. As in previous years Maui leads in quality of cane with 15.29 polarization of the cane and 88.9 purity of the first mill juice. This purity is higher than that of the last two years and with the exception of 1917, the polarization is higher than any year since 1913. Oahu comes next with 13.75 polarization and 85.40 purity. This polarization is lower than that of last year and the purity is the lowest yet recorded for this island. With the exception of 1917, the cane on Hawaii was better than for several years. On Kauai the polarization was lower than any year except 1918. The purity was lower than any year except 1918 and 1919.

For the whole group the quality of the cane was lower than in any year except 1918. Reference to Table 9, however, shows that excluding the plantations affected by the strike, compared with last year, there was an increase of 0.4 in the purity of the first mill juice, a slight increase in the polarization of the cane and a slight increase in fiber.

Milling.

The quality of the milling work was better than in any previous year. Some additions have been made to the milling equipment. These include adding a shredder and crusher to a nine-roller train, a crusher to a twelve-roller train, a shredder to a crusher and twelve-roller mill, adding a fourth mill to a crusher and nine-roller mill and adding a fifth mill to a crusher shredder and twelve-roller mill. All of these factories have benefitted in extraction because of the additions made.

The improvement in the milling work, however, has not been confined to these factories alone but has been general, 64% of the factories reporting a lower milling loss than last year. The average extraction has increased from 97.30 to 97.45 and the milling loss, or sugar lost per hundred fiber in the bagasse decreased from 2.97 to 2.75, though the cane was of slightly lower polarization, materially higher fiber content and a smaller amount of maceration was used. A further improvement is the reduction in the moisture content of the bagasse from 41.57 to 41.05.

In the factories unaffected by strike conditions, the improvement is much greater. In this case the extraction has increased by .34% and the milling loss decreased by .37%. In these factories the maceration increased slightly over the amount used last year.

In Table 3, the factories are arranged in the order of their milling loss. Two factories, Olowalu and Makee reduced this figure to less than half of what it was last season. Factories that have materially improved their standing in the tabulation are Olowalu, Makee, Pioneer, Hawaiian Sugar, Kekaha, McBryde, Kilauea

TABLE NO. 3.—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Maui Agr......	1.27	0.08	99.05	K(2),21RM66
2. Onomea	1.41	0.11	98.61	2RC60,S54,12RM66
3. Hilo	1.50	0.11	98.49	K,2RC60,12RM66
4. Hakalau	1.57	0.12	98.41	2RC54,12RM9-60,3-66
5. H. C. & S. Co...	1.62	0.10	98.92	K(4),2RC78(2),S72(2),12RM78(2)
6. Pepeekeo	1.90	0.15	98.13	2RC54,9RM60
7. Waimea	1.96	0.16	98.31	2RC48,12RM42
8. Olowalu	2.08	0.15	98.06	K,3RC48,9RM48
9. Paauhau	2.21	0.17	97.53	2RC60,12RM66
10. Kilauea	2.38	0.20	97.32	K,S,3RC60,9RM60
11. McBryde	2.45	0.19	97.45	K,S54,9RM84
12. Haw. Sug......	2.48	0.17	97.98	K,2RC72,S72,12RM78
13. Honomu	2.50	0.19	97.59	2RC60,9RM60
14. Pioneer	2.62	0.17	98.12	K,2RC72,S72,15RM72
15. Waianae	2.62	0.18	97.74	K,12RM60
16. Lihue	2.63	0.21	97.25	K,2RC72,S72,12RM78
17. Haw. Agr.	2.67	0.22	97.00	3RC60,12RM66
18. Makee	2.75	0.22	96.95	K,2RC72,S72,9RM72
19. Kekaha	2.86	0.21	97.62	2RC54,9RM60
20. Olaa	2.95	0.23	96.94	K,S72,12RM78
21. Laupahoehoe ..	2.97	0.22	97.14	K(2),11RM60
22. Kahuku	2.98	0.24	96.29	3RC60,S54,9RM72
23. Wailuku	3.00	0.21	97.24	K,2RC72,12RM78
24. Koloa	3.02	0.24	96.68	K,2RC60,12RM66
25. Waialua	3.03	0.23	97.04	K(2),14RM78
26. Oahu	3.08	0.21	97.50	K(2),2RC78(2),S72,12RM78(2)
27. Ewa	3.12	0.24	97.08	K(2),20RM78
28. Hutchinson	3.29	0.28	96.51	2RC60,9RM60
29. Honokaa	3.32	0.27	95.88	K(2),14RM2-60,12-66
30. Kaiwiki	3.56	0.27	96.34	K(2),11RM60
31. Kohala	3.64	0.27	96.45	K(2),S42,11RM60
32. Honolulu	3.68	0.26	96.65	K(2),S54,11RM78
33. Lihue, Han.....	3.70	0.29	96.01	K,2RC72,9RM78
34. Waiakea	3.93	0.31	95.81	K,S42,11RM60
35. Hamakua	4.09	0.32	95.47	K,2RC60,12RM60
36. Hawi	4.10	0.29	96.18	K(3),3RC48,12RM3-48,9-54,S42,9RM54
37. Kaeleku	4.70	0.38	94.78	K(2),11RM2-54,9-60
38. Halawa	7.47	0.56	92.58	K,2RC60,6RM50
39. Union Mill	8.40	0.65	90.29	K,9RM60
40. Kipahulu	10.89	0.82	88.65	K,5RM3-42,2-54
41. Niulii	12.1	0.87	89.09	K(2),9RM54

and Lihue. Those that have lost materially in relative rank are Ewa, Wailuku, Koloa, Olaa, Honakaa, Honolulu, Kaeleku and Waiakea. As has been pointed out before, a considerable improvement in the work from year to year is necessary for a factory to maintain its relative rank. Five factories have dropped from one to three places, though actually doing better work than last year.

Maui Agricultural Co. has again set a new record for milling loss, 1.27, though the extraction is identical with that of last year. For the first time too a factory equipped with a nine-roller mill and crusher, Pepeekeo, has finished a season with over 98 extraction and a milling loss under 2.0. The following table shows the improvement in milling during the past four seasons.

Milling Loss	No. of Factories			
	1917	1918	1919	1920
Under 1.5	0	2	2	2*
" 2.0	3	6	6	7
" 3.0	15	19	20	22
" 4.0	25	28	29	34
Over 4.0	14	9	10	7
Factories reporting	39	37	39	41

* A third factory exactly 1.5.

This year we have an excellent opportunity to compare a twelve and fifteen-roller mill working under practically identical conditions. The mills at Puunene have been so arranged that they can be operated either as two twelve-roller tandems or one fifteen. This season 20% of the crop was grounded with the fifteen-roller set. A similar comparison can be made at Pioneer, where the mill has been increased from twelve to fifteen rollers. In this case, however, the comparison is not so direct as the work of two different seasons must be compared and other changes have been made. In both cases the mill is preceded by a two-roller crusher and shredder. The comparisons follow:

	Puunene		Pioneer	
	12-Roller	15-Roller	12-Roller (1919)	15-Roller (1920)
Tons cane per hour	53.33	77.53	56.29	61.40
Tonnage ratio	1.51	1.84	1.88	1.71
Fiber % cane	10.44	10.74	11.42	11.01
Dilution	48.82	30.14	36.34	31.96
Extraction	98.90	98.98	97.45	98.12
Milling loss	1.70	1.44	3.38	2.62

In both cases the comparison is very favorable to the longer train.

TABLE NO. 4.

GRAVITY SOLIDS AND SUCROSE BALANCES.

Factory	GRAVITY SOLIDS PER 100 GRAVITY SOLIDS IN MIXED JUICE				SUCROSE PER 100 SUCROSE IN MIXED JUICE			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	4.4	79.0	12.5	4.1	0.5	91.4	5.6	2.5
Oahu	3.6	77.7	14.6	4.1	0.2	91.5	7.0	1.3
Maui Agr.	4.3	80.0	15.7	..	0.3	92.2	7.4	0.1
Pioneer	2.8	79.2	15.2	2.8	0.2	91.2	6.8	1.8
Waialua	2.0	70.4	20.0	7.6	0.4	82.9	10.0	6.7
Haw. Sug.	3.5	80.2	14.4	1.9	0.6	92.3	6.1	1.0
Onomea	5.8	78.5	13.8	1.9	0.1	92.8	5.8	1.3
Hakalau	4.3	77.0	15.1	3.6	0.2	89.8	6.9	3.1
Hilo	4.3	78.1	14.9	2.7	0.2	90.7	6.2	2.9
Wailuku	3.1	79.8	15.0	2.1	0.1	92.2	6.9	0.8
Haw. Agr.	3.9	78.1	16.4	1.6	0.1	90.3	7.5	2.1
Makee	2.5	69.3	21.5	6.7	0.6	83.8	10.6	5.0
Pepeekeo	4.4	79.1	13.9	2.6	0.1	92.9	5.7	1.3
Paauhau	5.8	75.8	16.6	1.8	0.3	91.7	7.6	0.4
Honomu	4.8	78.9	14.4	1.9	0.3	91.9	6.1	1.7
Hutchinson	3.3	80.2	12.8	3.7	0.1	92.0	6.1	1.8
Kohala	7.4	74.6	17.9	0.1	0.2	91.0	8.5	0.3
Kilauea	3.8	69.6	25.3	1.3	0.4	85.8	12.9	0.9

Boiling House Work.

The boiling house work has not been as satisfactory as the milling. The clarification, judging from the increase in purity from mixed juice to syrup, has been less satisfactory than in previous years. This increase, 1.33, is less than in any of the seven years during which this figure has been averaged. Approximately one-half of the factories report a larger increase than last year. The smaller increase reported by the remaining factories, however, brings the average down to the above figure. A smaller amount of lime has been used but it seems hardly probable that this decrease has been enough to materially affect the clarification.

Starting with a mixed juice purity lower than ever before, the smaller increase in purity has resulted in a syrup half a per cent lower than the previous low point reached last year. The increased amount of non-sugar adds to the duty imposed on the boiling house equipment and some allowance must be made for this in commenting on the quality of the boiling house work.

Considering only the factories not affected by strike conditions, we find that the purity of the mixed juice was slightly higher than a year ago. Here too, however, the increase in purity is smaller and the result is a syrup of approximately the same purity as last year.

The filter press work is also less satisfactory than before. For a number of years there has been a more or less gradual increase in the amount of press cake. This year, however, the press cake per 100 cane has increased from 2.32 to 2.63%, a very considerable increase. During the previous four seasons there has been a decrease in the polarization of the cake which has more than offset the increase in quantity and has resulted in a constantly decreasing loss. Three-quarters of the factories report an increased quantity of cake over last year, while about half of factories report an increase in the polarization.

No reasonable explanation for this sudden increase both in quantity and polarization occurs to the writer at the present time. There seems, however, to be some connection between the increased amount of press cake and the smaller increase in purity from mixed juice to syrup. Twelve out of eighteen factories reporting a larger amount of press cake report a smaller increase in purity compared with last year, while eleven out of nineteen factories reporting less press cake report a greater increase in purity. This suggests the possibility that a greater amount of cush cush has been allowed to pass the mill screens and has had a deleterious effect on the clarification.

The evaporation too has been less satisfactory than formerly. Though less maceration was used, resulting in a smaller quantity of mixed juice per cent cane than last year, the density of the syrup was lower than in any year since 1914. The amount of water evaporated per ton of cane was smaller than during the two preceeding seasons. There is a material heat economy in concentrating the syrup to as high a density as practicable in the evaporators. This point is not below 65 brix except possibly for the part of the syrup that is held over night in factories operating only in the day time.

Eliminating the figures from factories affected by the strike does not change the above conclusions either in regard to filter press work or evaporation, except that in the remaining factories a somewhat increased amount of maceration was

TABLE NO. 5.

APPARENT BOILING HOUSE RECOVERY.

Comparing percent. available sucrose in the syrup (calculated by formula) with percent. polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.	92.76	92.73	100.0
Oahu	90.48	92.35	102.1
Ewa	87.21	86.23	98.9
Maui Agr.	92.72	92.44 †	99.7
Pioneer	92.33	91.46	99.1
Waialua	88.36	89.07	100.8
Haw. Sug.	93.06	93.47	100.4
Olaa	91.57	90.25	98.6
Onomea	93.37	93.01	99.6
Hakalau	92.13	90.13	97.8
Kekaha	92.14	90.20	97.9
McBryde	89.48	86.49	96.7
Hilo	93.57	90.99	97.2
Wailuku	92.04	92.89	100.9
Haw. Agr.	92.57	90.78	98.1
Lihue	87.50	84.92	97.1
Lihue, Han.	88.53	87.94	99.3
Waiakea	89.93	86.63	96.3
Makee	87.18	84.90	97.4
Honokaa	90.12	88.30	98.0
Laupahoehoe	93.43	91.06	97.7
Pepeekeo	93.40	93.50	100.1
Kahuku	87.07	82.84	95.1
Koloa	89.18	86.22	96.7
Hamakua	88.81	82.96	93.4
Hawi	92.37	87.06	94.3
Paauhau	91.37	91.92	100.6
Honomu	93.60	92.41	98.7
Hutchinson	92.08	92.45	100.4
Kaeleku	86.74	87.36	100.7
Kohala	92.27	90.82	98.4
Kaiwiki	91.45	89.45	97.8
Waianae	89.94	86.70	96.4
Kilauea	86.22	86.88	100.8
Niulii	90.36	83.75	92.7
Halawa	89.17	82.78	92.8
Union Mill	86.82	87.75	101.1
Olowalu	88.85	85.00	95.6
Waimea	90.03	88.12	97.9
Kipahulu	91.89	88.12	95.9

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1% has been taken. 38 has been used when the gravity purity of the molasses has not been reported.

† Sucrose.

used, necessitating increased evaporation to bring the syrup to the same density as before.

The polarization of the commercial sugar has remained approximately the same as it was the previous year.

This year the gravity purity of the final molasses has increased from 37.95 to 38.75. Eighty-five per cent of this increase has been due to poorer results in the factories affected by the strike.

During the preceeding two seasons the attention given the low grade work resulted in a very satisfactory reduction in the purity of the final molasses, though the average purity attained was far from the possible limit. However, last year, the loss in molasses was lower than it had been for several seasons, notwithstanding the fact that the syrup purity was the lowest recorded up to that time.

This year the loss in molasses is the largest yet reported. The decreased purity of the syrup is largely responsible for this. In most of the factories affected by the strike, due to delay in harvesting, juices were of low purity and the low grade equipment was overloaded. The average molasses purity reported from the remaining factories, however, has shown no improvement, in fact reference to Table 9 shows an apparent increase. This increase is due to the fact that four small factories, producing high purity molasses, have this year reported molasses losses for the first time. This has influenced the average almost exactly to the extent of the above-mentioned increase shown in Table 9.

That the importance of this work may not be underestimated, the writer would call attention to the fact that with syrup and molasses of about the present purity a decrease of one per cent in the purity of the final molasses means an increased recovery of slightly under one-half of one per cent.

Gravity Solids and Sucrose Balances.

These balances for the factories reporting the necessary data appear in Table 4. These data have been received from eighteen factories, the same number as last year.

Boiling House Recovery.

These Tables, 5 and 6, are to a large extent a check on the chemical control. Table 5 shows the boiling house recovery, based on polarization, compared with the theoretical recovery on the same basis. In calculating this table it is necessary to make certain assumptions explained in the foot note under the table. On account of these assumptions being based on averages the available may vary in individual cases. Comparison of the recoveries, however, based on polarization and sucrose, over a period of years indicates that the figure for recovered on available in Table 5 is probably in all cases within one per cent of the truth. Should this figure then appear as 101% or over it is practically certain that there have been errors in the control. A figure of 99% or under may indicate errors in the control or an actual loss.

For the factories furnishing the necessary data the more reliable figures based on true sucrose are tabulated in Table 6. There appears to be no reason why the recovery on this basis should be over 100% except for inaccuracies in the control. Eighteen factories have furnished the data necessary for inclusion in this table.

With the laboratory facilities and personnel now available at most of the

TABLE NO. 6.

TRUE BOILING HOUSE RECOVERY.

Comparing percent. sucrose available and recovered.

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.	92.88	91.86	98.9
Oahu	90.57	91.68	101.2
Maui Agr.	92.72	92.48	99.7
Pioneer	92.23	91.38	99.1
Waialua	88.34	83.23	94.2
Haw. Sug.	93.12	92.86	99.7
Onomea	93.64	92.89	99.2
Hakalau	92.29	89.98	97.5
Hilo	93.61	90.88	97.1
Wailuku	92.06	92.29	100.3
Haw. Agr.	92.67	90.39	97.5
Makee	87.19	84.31	96.7
Pepeekeo	93.41	92.99	99.6
Paauhau	91.13	91.98	100.9
Honomu	93.55	92.18	98.5
Hutchinson	92.19	92.09	99.9
Kohala	91.71	91.18	99.4
Kilauea	86.55	86.14	99.5

TABLE NO. 7.

PERCENT MOLASSES PRODUCED ON THEORETICAL.

H. C. & S. Co.	76.3	Makee	76.4
Oahu	78.0	Honokaa	90.0
Ewa	96.4	Laupahoehoe	98.2
Maui Agr.	100.5	Pepeekeo	84.1
Pioneer	83.5	Kahuku	81.0
Waialua	80.7	Koloa	90.0
Haw. Sug.	88.2	Hamakua	65.7
Olaa	101.3	Paauhau	89.8
Honolulu	85.5	Honomu	87.9
Onomea	83.4	Hutchinson	76.9
Hakalau	78.9	Kaeleku	84.1
Kekaha	75.4	Kohala	101.4
McBryde	96.0	Kaiwiki	80.1
Hilo	82.9	Kilauea	95.2
Wailuku	89.2	Niulii	81.4
Haw. Agr.	90.3	Olowalu	73.0
Waiakea	78.5		

factories it should be practicable to make the extra determinations necessary for a true surcrose balance and a calculation of the recovery on the same basis, particularly since the simplification of these determinations by Walker's modification. The extra determinations required are sucrose in mixed juice, syrup and sugar. The writer considers it very desirable that the sucrose determination be made so that the uncertainty of estimating the difference between polarization and sucrose will be avoided.

In the Synopsis last year attention was called to the discrepancy between the molasses accounted for at the different factories and the theoretical amount based on gravity solids. Since that time the writer's attention has been called to the fact that a part of the diference is due to the method of determining gravity solids. These are calculated from the brix. The concentration of the non-sugar in the syrup is comparatively low while in the molasses it is high. This difference in concentration affects the brix in such a manner that a somewhat smaller amount of solids than the theoretical will be found in the molasses even if there has been no loss. This, however, does not account for the large variations in the figures from different factories and Table 7 showing the % molasses accounted for on the theoretical has again been included to the end that attention be called to these discrepancies and if possible the cause determined.

Factory Efficiency.

The standing of the factories in the order of their efficiency is shown in Table 8. This table has been rearranged, the milling, boiling house and over all efficiency being shown separately.

The arbitrary standard used in calculating the efficiency on a per centage basis is the same as that used during the two preceeding seasons. It is a factory obtaining 100% extraction, reducing the molasses to thirty gravity purity and having no loss other than molasses. Factories showing a recovery of 101% or more on the theoretical (Table 5) have been omitted from this table.

An interesting fact emphasized by this new arrangement is that as a rule the factories obtaining a high extraction also have a high boiling house efficiency.

Losses in Manufacture.

While there has been a reduction in the loss in bagasse, the gain due to more efficient milling work has been more than offset by the lower recovery in the boiling house. There has been an increase in press cake, molasses and undetermined losses bringing the total to 12.65, a figure higher than any since 1914.

The calculations in this Synopsis have been made almost entirely by Mr. A. Brodie.

TABLE NO. 8.

FACTORY EFFICIENCY.

Showing comparative standing of the plantations on the basis of the entire factory work.

No.	Factory	EFFICIENCY Milling	Boiling House	Over All
1	Onomea	98.61	98.09	96.89
2	Pepeekeo	98.13	98.79	96.65
3	H. C. & S. Co.	98.92	97.18	96.29
4	Haw. Sug.	97.98	98.02	96.19
5	Maui Agr.	99.05	96.68	95.86
6	Wailuku	97.24	98.07	95.53
7	Paauhau	97.53	97.67	95.43
8	Pioneer	98.12	96.45	94.84
9	Honomu	97.59	96.94	94.82
10	Hilo	98.49	95.63	94.27
11	Hutchinson	96.51	97.23	94.13
12	Hakalau	98.41	95.10	93.75
13	Haw. Agr.	97.00	95.50	92.82
14	Kekaha	97.62	94.92	92.78
15	Laupahoehoe	97.14	95.29	92.74
16	Olaa	96.94	95.35	92.67
17	Waimea	98.31	94.12	92.67
18	Kohala	96.45	95.86	92.59
19	Kilauea	97.32	94.72	92.42
20	Kaiwiki	96.34	94.67	91.49
21	Lihue, Han.	96.01	94.58	91.36
22	Ewa	97.08	93.70	91.23
23	Honokaa	95.88	94.75	91.16
24	Waianae	97.74	92.58	90.59
25	Koloa	96.68	93.01	90.30
26	McBryde	97.45	92.26	90.12
27	Kaeleku	94.78	94.54	89.99
28	Waialua	97.04	92.37	89.97
29	Lihue	97.25	91.75	89.44
30	Makee	96.95	91.85	89.37
31	Olowalu	98.06	90.59	89.03
32	Waiakea	95.81	92.12	88.47
33	Hawi	96.18	91.61	88.46
34	Kahuku	96.29	91.29	88.29
35	Hamakua	95.47	89.43	85.72
36	Kipahulu	88.65	92.10	81.89
37	Halawa	92.58	87.22	80.89
38	Niulii	89.09	86.93	77.64

TABLE NO. 9.

TRUE AVERAGES.

	Factories Not Affected by Strike Conditions		All Factories
	1919	1920	1920
Cane—			
Polarization	13.58	13.61	13.64
Fiber	12.61	12.63	12.64
Tons per ton sugar	8.03	8.06	8.12
Bagasse—			
Polarization	1.69	1.50	1.56
Moisture	41.28	40.68	41.05
Fiber	56.32	57.16	56.68
Pol. % polarization of cane	2.78	2.44	2.55
Milling loss	3.00	2.63	2.75
Weight % cane	22.38	22.09	22.29
First Mill Juice—			
Brix	18.94	19.16	19.32
Polarization	16.56	16.83	16.85
Purity	87.43	97.83	87.24
"Java ratio"	82.0	80.9	80.9
Mixed Juice—			
Brix	13.46	13.45	13.48
Polarization	11.35	11.37	11.31
Purity	84.36	84.50	83.87
Weight % cane	116.32	116.85	117.35
Extraction	97.22	97.56	97.45
Extraction ratio	0.22	0.19	0.20
Last Mill Juice—			
Polarization	1.79	1.73	1.65
Purity	68.72	68.83	68.20
Maceration % cane	38.69	38.93	39.95
Syrup—			
Brix	61.62	60.98	61.34
Purity	85.71	85.74	85.20
Increase in purity	1.35	1.24	1.33
Press Cake—			
Polarization	1.38	1.60	1.65
Weight % cane	2.29	2.58	2.63
Pol. % polarization of cane	0.23	0.30	0.31
Lime used % cane	0.076	0.072	0.071
Commercial Sugar—			
Polarization	96.31	96.40	96.36
Moisture	1.00	0.96	0.97
Pol. % polarization of cane	88.29	87.61	87.35
Pol. % polarization of juice	90.82	90.02	89.56
Final Molasses—			
Weight % cane	3.01	3.06	3.24
Sucrose % polarization of cane	7.26	7.45	8.03
Sucrose % polariaztion of juice	7.44	7.64	8.24
Gravity solids	86.21	86.82	87.42
Gravity purity	38.26	38.38	38.75

TABLE NO. 10.

SUMMARY OF LOSSES.

FACTORY	Pounds Polarization per Ton of Cane: Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Polarization per 100 Cane: Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Polarization per 100 Polarization of Cane: Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Syrup Purity	FACTORY
H. C. & S. Co.	3.4	1.4	13.0	...	4.8	27.6	0.17	0.07	0.90	...	0.24	1.38	1.08	0.45	5.65	...	1.50	8.68	86.90	H. C. & S. Co.
Oahu	7.4	0.6	20.4	...	1.6	30.0 *	0.37	0.03	1.02	...	0.08	1.50 *	2.50	0.21	6.93	...	0.51	10.15 *	84.8	Oahu
Ewa	7.6	1.2	32.6	...	1.8	43.2	0.38	0.06	1.63	...	0.09	2.16	2.92	0.51	12.62	...	0.68	16.73	81.15	Ewa
Maui Agr.	3.0	0.8	23.0	...	0.4	27.2 †	0.15	0.04	1.15	...	0.02	1.36 †	0.95	0.28	7.35	...	0.12	8.70 †	88.46	Maui. Agr.
Pioneer	5.8	0.6	20.6	...	5.0	32.0	0.29	0.03	1.03	...	0.25	1.60	1.88	0.17	6.70	...	1.66	10.41	86.26	Pioneer
Waialua	8.0	1.2	27.0	...	8.6	44.8	0.40	0.06	1.35	...	0.43	2.24	2.96	0.45	10.06	...	3.23	16.70	83.3	Waialua
Haw. Sug.	5.8	1.8	17.4	...	0.8	25.8	0.29	0.09	0.87	...	0.04	1.29	2.02	0.62	6.06	...	0.30	9.00	86.47	Haw. Sug.
Olaa	7.6	0.8	22.4	...	1.2	32.0	0.38	0.04	1.12	...	0.06	1.60	3.06	0.34	8.94	...	0.48	12.82	86.0	Olaa
Honolulu	9.6	1.0	28.2	...	...	...	0.48	0.05	1.41	...	...	...	3.35	0.35	9.92	...	...	...	85.65	Honolulu
Onomea	3.6	0.2	14.8	...	2.8	21.4	0.18	0.01	0.74	...	0.14	1.07	1.39	0.08	5.77	0.02	1.16	8.36	86.4	Onomea
Hakalau	4.2	0.4	18.2	...	7.6	30.4	0.21	0.02	0.91	...	0.38	1.52	1.59	0.16	6.87	...	2.83	11.45	86.3	Hakalau
Kekaha	6.6	1.2	22.4	...	3.8	34.0	0.33	0.06	1.12	...	0.19	1.70	2.38	0.41	8.14	...	1.39	12.32	86.3	Kekaha
McBryde	6.6	0.2	29.6	...	4.8	41.2	0.33	0.01	1.48	...	0.24	2.06	2.55	0.10	11.35	...	1.80	15.80	84.6	McBryde
Hilo	4.0	0.6	16.6	...	7.2	28.4	0.20	0.03	0.83	...	0.36	1.42	1.51	0.22	6.13	...	2.73	10.59	87.00	Hilo
Wailuku	8.0	0.4	19.6	...	0.4	28.4	0.40	0.02	0.98	...	0.02	1.42	2.76	0.14	6.77	...	0.14	9.81	85.82	Wailuku
Haw. Agr.	7.2	0.2	17.4	...	3.8	28.6	0.36	0.01	0.87	...	0.19	1.43	3.00	0.08	7.34	...	1.60	12.02	86.88	Haw. Agr.
Lihue	6.8	1.0	...	...	36.6	44.4	0.34	0.05	...	...	1.83	2.22	2.75	0.39	...	...	14.61	17.75	82.21	Lihue
Lihue, Han.	10.4	0.8	...	...	29.8	41.0	0.52	0.04	...	...	1.49	2.05	3.99	0.31	...	...	11.55	15.85	82.9	Lihue, Han.
Waiakea	10.8	0.4	22.8	...	10.2	44.2	0.54	0.02	1.14	...	0.51	2.21	4.19	0.19	8.87	...	3.92	17.17	84.86	Waiakea
Makee	7.4	1.6	25.4	...	10.2	44.6	0.37	0.08	1.27	...	0.51	2.23	3.05	0.62	10.39	...	4.16	18.22	81.98	Makee
Honokaa	10.0	0.4	22.6	...	4.6	37.6	0.50	0.02	1.13	...	0.23	1.88	4.12	0.18	9.30	...	1.96	15.50	83.66	Honokaa
Laupahoehoe	7.8	0.4	20.0	...	3.4	31.6	0.39	0.02	1.00	...	0.17	1.58	2.86	0.12	7.40	...	1.27	11.65	87.85	Laupahoehoe
Pepeekeo	4.8	0.4	14.4	...	2.0	21.6	0.24	0.02	0.72	...	0.10	1.08	1.87	0.13	5.58	...	0.78	8.36	86.17	Pepeekeo
Kahuku	9.2	0.4	28.8	...	12.2	50.6	0.46	0.02	1.44	...	0.61	2.53	3.71	0.17	11.60	...	4.89	20.37	79.86	Kahuku
Koloa	8.4	0.6	27.0	...	6.8	42.8	0.42	0.03	1.35	...	0.34	2.14	3.32	0.25	10.60	...	2.69	16.86	82.5	Koloa
Hamakua	11.6	0.4	22.4	...	19.4	53.8	0.58	0.02	1.12	...	0.97	2.69	4.53	0.17	8.71	...	7.53	20.94	82.54	Hamakua
Hawi	11.0	1.0	...	...	35.6	47.6	0.55	0.05	...	...	1.78	2.38	3.82	0.34	...	...	12.40	16.56	86.26	Hawi
Paauhau	6.2	0.8	19.0	...	1.0	27.0	0.31	0.04	0.95	...	0.05	1.35	2.47	0.32	7.50	...	0.36	10.65	84.8	Paauhau
Honomu	6.4	0.8	15.8	...	3.8	26.8	0.32	0.04	0.79	...	0.19	1.34	2.41	0.31	5.98	...	1.40	10.10	86.9	Honomu
Hutchinson	8.4	0.2	14.2	...	3.2	26.0	0.42	0.01	0.71	...	0.16	1.30	3.49	0.10	5.92	...	1.36	10.87	86.8	Hutchinson
Kaeleku	12.8	1.0	25.8	...	3.4	43.0	0.64	0.05	1.29	...	0.17	2.15	5.22	0.44	10.50	...	1.42	17.58	81.87	Kaeleku
Kohala	9.6	0.6	22.0	...	1.8	34.0	0.48	0.03	1.10	...	0.09	1.70	3.55	0.19	8.19	...	0.65	12.58	86.3	Kohala
Kaiwiki	9.8	0.8	19.8	...	7.2	37.6	0.49	0.04	0.99	...	0.36	1.88	3.66	0.29	7.41	...	2.72	14.08	85.2	Kaiwiki
Waianae	6.4	1.0	...	...	37.0	44.4	0.32	0.05	...	...	1.85	2.22	2.26	0.36	...	...	12.95	15.57	84.14	Waianae
Kilauea	6.2	0.8	29.6	...	...	36.6	0.31	0.04	1.48	...	...	1.83	2.68	0.28	12.70	...	0.02	15.78	81.1	Kilauea
Waimanalo	...	2.4	...	...	...	...	...	0.12	...	...	...	...	...	...	...	...	...	...	....	Waimanalo
Niulii	30.4	2.2	26.4	...	13.8	72.8	1.52	0.11	1.32	...	0.69	3.64	10.91	0.76	9.42	...	1.94	26.03	87.7	Niulii
Halawa	19.8	0.6	...	...	42.4	62.8	0.99	0.03	...	...	2.12	3.14	7.42	0.32	...	...	15.90	23.54	85.73	Halawa
Union Mill	25.2	1.8	...	...	28.4	55.4 *	1.26	0.09	...	...	1.42	2.77 *	9.71	0.68	...	...	10.98	21.37 *	83.58	Union Mill
Olowalu	5.6	0.6	26.4	...	15.2	47.8	0.28	0.03	1.32	...	0.76	2.39	1.94	0.22	9.33	...	5.35	16.84	84.44	Olowalu
Waimea	4.2	1.4	...	...	28.8	34.4	0.21	0.07	...	...	1.44	1.72	1.69	0.59	...	...	11.61	13.89	83.50	Waimea
Kipahulu	30.6	3.2	...	...	27.6	61.4	1.53	0.16	...	...	1.38	3.07	11.43	1.23	...	...	10.30	22.96	85.81	Kipahulu

* A comparison of the available sucosre in the juice with the amount recovered in the boiling house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

Factory	Factory No.	Milling Plant (Sizes in Inches)	CANE: Polarization	CANE: % Fiber	CANE: Tons per ton commercial sugar	CANE: Tons ground per hour	CANE: Tonnage ratio	BAGASSE: Polarization	BAGASSE: % Moisture	BAGASSE: % Fiber	BAGASSE: Pol. per 100 cane	BAGASSE: Pol. per 100 pol. of cane	BAGASSE: Pol. per 100 Fiber "Milling Loss"	BAGASSE: Weight per 100 cane
H. C. & S. Co..	6	K(4),2RC78(2),S72(2),12RM78(2).....	15.87	10.52	6.54	58.08§	1.59	0.94	40.57	57.88	0.17	1.08	1.62	18.18
Oahu..........	20	K(2),2RC78(2),S72,12RM78(2)........	14.74	11.96	7.26	56.39§	1.60	1.71	41.75	55.77	0.37	2.50	3.08	21.46
Ewa..........	5	K(2),20RM78........................	12.93	12.06	8.95	60.23	1.22	1.64	44.90	52.57	0.38	2.92	3.12	22.94
Maui Agr......	21	K(2),21RM66........................	15.61	11.60	6.80	59.73	1.69	0.72	42.26	56.65	0.15	0.95	1.27	20.48
Pioneer........	10	K,2RC72,S72,15RM72.................	15.32	11.01	7.03	61.40	1.71	1.45	42.55	55.25	0.29	1.88	2.62	19.92
Waialua.......	17	K(2),14RM78........................	13.40	13.06	8.62	51.80	1.47	1.73	40.34	57.05	0.40	2.96	3.03	22.91
Haw. Sug......	16	K,2RC72,S72,12RM78.................	14.35	11.68	7.38	42.39	1.20	1.40	41.69	56.41	0.29	2.02	2.48	20.69
Olaa..........	36	K,S72,12RM78.......................	12.52	13.04	8.87	49.56	1.76	1.60	43.83	53.87	0.38	3.06	2.95	24.04
Honolulu......	13	K(2),S54,11RM78....................	14.24	12.96	8.41	34.76	1.23	2.01	42.26	54.63	0.48	3.35	3.68	23.71
Onomea........	34	2RC60,S54,12RM66...................	12.81	12.60	8.23	37.03	1.47	0.86	37.78	60.87	0.18	1.39	1.41	20.71
Hakalau.......	7	2RC54,12RM9-60,3-66................	13.26	13.49	8.21	29.60	1.42	0.98	36.21	62.29	0.21	1.59	1.57	21.66
Kekaha.......	25	2RC54,9RM60........................	13.78	11.44	7.98	28.98	1.74	1.65	39.97	57.67	0.33	2.38	2.86	19.84
McBryde......	12	K,S54,9RM84........................	13.04	13.60	8.76	35.33	1.44	1.39	41.23	56.78	0.33	2.55	2.45	23.97
Hilo..........	33	K,2RC60,12RM66.....................	13.46	13.54	8.02	35.89	1.42	0.95	35.35	63.37	0.20	1.51	1.50	21.43
Wailuku.......	2	K,2RC72,12RM78.....................	14.42	13.25	7.37	39.30	1.12	1.70	41.02	56.68	0.40	2.76	3.00	23.38
Haw. Agr.....	30	3RC60,12RM66.......................	11.91	13.42	9.23	45.79	1.82	1.56	39.46	58.48	0.36	3.00	2.67	22.93
Lihue.........	27	K,2RC72,S72,12RM78.................	12.51	13.11	9.37	45.15	1.28	1.44	43.30	54.67	0.34	2.75	2.63	23.98
Lihue, Han....	46	K,2RC72,9RM78......................	12.92	13.93	8.85	33.65	1.18	1.99	42.90	53.78	0.52	3.99	3.70	25.91
Waiakea.......	3	K,S42,11RM60.......................	12.90	13.71	9.01	22.34	1.57	2.24	39 98	57.00	0.54	4.19	3.93	24.05
Makee........	14	K,2RC72,S72,9RM72..................	12.26	13.61	9.67	41.50	1.73	1.58	40.00	57.56	0.37	3.05	2.75	23.63
Honokaa......	35	K(2),14RM2-60,12-66................	12.14	15 08	9.39	31.89	1.27	1.82	42.59	54.80	0.50	4.12	3.32	27.52
Laupahoehoe...	41	K(2),11RM60........................	13.51	13.00	8.07	25.73	1.54	1.75	38.77	58.88	0.39	2.86	2.97	22.08
Pepeekeo......	19	2RC54,9RM60........................	12.85	12.66	8.21	25.63	1.54	1.14	38.37	60.07	0.24	1.87	1.90	21.06
Kahuku.......	43	3RC60,S54,9RM72....................	12.45	15.52	9.72	22.02	0.92	1.68	41.04	56.31	0.46	3.71	2.98	27.50
Koloa.........	38	K,2RC60,12RM66.....................	12.69	13.97	9.11	32.21	1.28	1.68	41.66	55.66	0.42	3.32	3.02	25.05
Hamakua......	15	K,2RC60,12RM60.....................	12.84	14.21	9.43	22.96	1.10	2.20	43.04	53.80	0.58	4.53	4.09	26.43
Hawi.........	26	K(3),3RC48,12RM3-48,9-54,S42,9RM54.	14.33	13.34	8.05	30.31	1.13	2.29	40.80	55.84	0.55	3.82	4.10	23.88
Paauhau.......	24	2RC60,12RM66.......................	12.67	14.11	8.50	26.98	1.07	1.30	39.23	58.90	0.31	2.47	2.21	23.96
Honomu.......	37	2RC60,9RM60........................	13.23	12.72	8.11	21.55	1.29	1.54	36.05	61.71	0.32	2.41	2.50	20.61
Hutchinson....	31	2RC60,9RM60........................	11.93	12.68	9.05	26.12	1.57	1.89	39.99	57.53	0.42	3.49	3.29	22.05
Kaeleku.......	47	K(2),11RM2-54,9-60.................	12.27	13.66	9.53	23.95	1.44	2.60	40.75	55.50	0.64	5.22	4.70	24.62
Kohala........	40	K(2),S42,11RM60....................	13.43	12.98	8.23	24.73	1.48	2.03	41.66	55.77	0.48	3.55	3.64	23.47
Kaiwiki.......	32	K(2),11RM60........................	13.39	13.75	8.34	22.23	1.33	2.08	38.81	58.25	0.49	3.66	3.56	23.61
Waianae.......	9	K,12RM60...........................	14.26	12.30	8.02	26.32	1.58	1.51	40.41	57.56	0.32	2.26	2.62	21.37
Kilauea.......	23	K,S,3RC60,9RM60....................	11.63	13.14	9.87	25.43	1.52	1.38	39.95	58.01	0.31	2.68	2.38	22.67
Waimanalo....	1	K,8RM6-54,2-60.....................	....	....	10.22	17.18	1.69	...	....	....	...	...	...	...
Niulii.........	39	K(2),9RM54.........................	13.97	12.6	9.31	13.12	1.30	5.5	47.8	45.5	1.52	10.91	12.1	27.7
Halawa........	29	K,2RC60,6RM50......................	13.31	13.25	9.37	14.07	1.39	3.89	42.85	52.22	0.99	7.42	7.47	25.4
Union Mill....	11	K,9RM60............................	12.96	14.97	9.39	18.31	1.46	4.09	46.06	48.69	1.26	9.71	8.40	30.7
Olowalu.......	18	K,3RC48,9RM48......................	14.19	13.10	8.16	16.06	1.51	1.24	39.06	59.09	0.28	1.94	2.08	22.1
Waimea.......	4	2RC48,12RM42.......................	12.40	10.75	9.02	15.35	1.50	1.18	38.10	60.21	0.21	1.69	1.96	17.8
Kipahulu......	44	K,5RM3-42,2-54.....................	13.37	13.80	9.22	11.17	2.06	4.85	49.41	44.53	1.53	11.43	10.89	31.1
True Average, 1920...		....	13.64	12.64	8.12	....	...	1.56	41.05	56.68	0.35	2.55	2.75	22.
" " 1919...		....	13.74	12.49	7.94	....	...	1.67	41.57	56.05	0.37	2.70	2.97	22.
" " 1918...		....	12.97	12.50	8.51	....	...	1.59	42.70	55.04	0.36	2.79	2.90	22.
" " 1917...		....	13.76	12.62	8.03	....	...	1.78	42.26	55.31	0.41	2.95	3.22	22.
" " 1916...		....	13.45	12.74	8.16	....	...	1.81	42.49	54.98	0.42	3.13	3.30	23
" " 1915...		....	13.77	12.51	7.98	....	...	2.17	43.87	53.07	0.51	3.72	4.09	23
" " 1914...		....	13.78	12.74	8.13	....	...	2.49	45.72	50.87	0.62	4.52	4.89	25
" " 1913...		....	14.05	12.85	8.14	....	...	3,07	47.11	48.71	0.81	5.75	6.30	2[illegible]
" " 1912...		....	14.34	12.67	7.99	....	...	3.43	....	49.57	0.88	6.11	6.92	2[illegible]
" " 1911...		....	13.99	12.85	8.16	....	...	3.55	....	49.31	0.93	6.41	7.20	2[illegible]

* Sucrose. † Refined sugar. ‡ 1920 crop

Factory	Factory No.	MILLING PLANT (Sizes in Inches)	B ROLLERS—TONS: First Set: Number	Distance Apart Inches	Distance from Conveyor Inches	4th Mill	5th Mill	6th Mill	7th Mill	Tons Cane per Hour	Tonnage Ratio	Factory No.	Factory
H. C. & S. Co..	6	K(2),2RC34x78,S72,12RM34x78..	28	9	24	525	....	....	....	58.08*	1.59	6	H. C. & S.Co.
" ..	6	K(2),2RC34x78,S72,12RM34x78..	28	9	24	525	....	....	....			6	"
Oahu.........	20	K,2RC32x78,12RM34x78.........	26	4	24	462	....	....	....	56.39†	1.60	20	Oahu
"	20	K,2RC35x78,S72,12RM34x78.....	11	7	5	473	....	....	....			20	"
Ewa..........	5	K(2),20RM2-32x78,18-34x78.....	72	.....	10	379	406	403	378	60.23	1.22	5	Ewa
Maui Agr......	21	K(2),21RM34x66...............	72	7/8	10	486	260	230	380	59.73	1.69	21	Maui Agr.
Pioneer.......	10	K,2RC34x72,S72,15RM34x72.....	27	2 1/4	8	360	375	....	....	61.40	1.71	10	Pioneer
Waialua.......	17	K(2),14RM2-33x78,12-34x78......	50	5 1/4	12	420	420	....	....	51.80	1.47	17	Waialua
Haw. Sug......	16	K,2RC26x72,S72,12RM34x78.....	38	1 1/2	8	480	....	....	....	42.39	1.20	16	Haw. Sug.
Olaa..........	36	K,S72,12RM34x78..............	46	.....	5	410	....	....	....	49.56	1.76	36	Olaa
Honolulu......	13	K(2),S54,11RM34x78...........	24	6	18	450	....	....	....	34.76	1.23	13	Honolulu
Onomea.......	34	2RC28x60,S54,12RM32x66.......	..	.....	.....	418	....	....	....	37.03	1.47	34	Onomea
Hakalau.......	7	2RC24x54,12RM9-32x60,3-32x66..	..	.....	.....	380	....	....	....	29.60	1.42	7	Hakalau
Kekaha.......	25	2RC24x54,9RM32x60............	..	.....	.....	....	....	....	....	28.98	1.74	25	Kekaha
McBryde......	12	K,S54,9RM34x84...............	24	6	4	....	....	....	....	35.33	1.44	12	McBryde
Hilo..........	33	K,2RC24x60,12RM32x66.........	10	6	10	430	....	....	....	35.89	1.42	33	Hilo
Wailuku.......	2	K,2RC26x72,12RM34x78.........	10	6	18	420	....	....	....	39.30	1.12	2	Wailuku
Haw. Agr.....	30	3RC32x60,12RM32x66...........	..	.....	.....	504	....	....	....	45.79	1.82	30	Haw. Agr.
Lihue.........	27	K,2RC26x72,S72,12RM34x78.....	10	6	11	480	....	....	....	45.15	1.28	27	Lihue
Lihue, Han....	46	K,2RC26x72,9RM34x78..........	11	6 1/4	10	....	....	....	....	33.65	1.18	46	Lihue, Han.
Waaikea......	3	K,S42,11RM2-28x60,9-32x60......	38	3	2	272	....	....	....	22.34	1.57	3	Waiakea
Makee........	14	K,2RC34x72,S72,9RM34x72......	12	6	30	....	....	....	....	41.50	1.73	14	Makee
Honokaa......	35	K(2),14RM2-30x60,12-32x66.....	68	1 3/4	16	321	395	....	....	31.89	1.27	35	Honokaa
Laupahoehoe..	41	K(2),11RM2-30x60,9-32x60......	16	3 3/4	1 1/4	373	....	....	....	25.73	1.54	41	Laupahoehoe
Pepeekeo......	19	2RC24x54,9RM6-32x60,3-30x60...	..	.....	.....	....	....	....	....	25.63	1.54	19	Pepeekeo
Kahuku.......	43	3RC30x60,S54,9RM34x72........	..	.....	.....	....	....	....	....	22.02	0.92	43	Kahuku
Koloa.........	38	K,2RC24x60,12RM32x66.........	24	6	6	400	....	....	....	32.21	1.28	38	Koloa
Hamakua......	15	K,2RC31x60,12RM32x60.........	60	1	1 1/2	331	....	....	....	22.96	1.10	15	Hamakua
Hawi.........	26	K,3RC26x48,12RM3-26x48,9-30x54	14	3 1/4	1 1/4	300	....	....	....	30.31	1.13	26	Hawi
"	26	K(2),S42,9RM30x54............	8	7	6	....	....	....	....			26	"
Paauhau.......	24	2RC24x60,12RM32x66...........	..	.....	.....	408	....	....	....	26.98	1.07	24	Paauhau
Honomu.......	37	2RC30x60,9RM32x60............	..	.....	.....	....	....	....	....	21.55	1.29	37	Honomu
Hutchinson....	31	2RC30x60,9RM32x60............	..	.....	.....	....	....	....	....	26.12	1.57	31	Hutchinson
Kaeleku.......	47	K(2),11RM2-24x54,9-32x60......	9	5 1/2	8	354	....	....	....	23.95	1.44	47	Kaeleku
Kohala........	40	K(2),S42,11RM2-30x60,9-32x60...	12	4	18	380	....	....	....	24.73	1.48	40	Kohala
Kaiwiki.......	32	K(2),11RM2-26x60,9-32x60......	18	3	1 1/2	368	....	....	....	22.23	1.33	32	Kaiwiki
Waianae......	9	K,12RM9-30x60,3-32x60.........	12	4 1/2	8	347	....	....	....	26.32	1.58	9	Waianae
Kilauea.......	23	K,S,3RC31x60,9RM32x60........	10	6	1 1/2	....	....	....	....	25.43	1.52	23	Kilauea
Waimanalo....	1	K,8RM6-26x54,2-30x60..........	8	6	8	....	....	....	....	17.18	1.69	1	Waimanalo
Niulii.........	39	K(2),9RM30x54................	9	.....	3 3/4	....	....	....	....	13.12	1.30	39	Niulii
Halawa.......	29	K,2RC30x60,6RM26x50..........	20	4	3	....	....	....	....	14.07	1.39	29	Halawa
Union Mill....	11	K,9RM30x60...................	16	3 7/8	3 1/2	....	....	....	....	18.31	1.46	11	Union Mill
Olowalu.......	18	K,3RC28x48,9RM27x48..........	16	3	2 1/4	....	....	....	....	16.06	1.51	18	Olowalu
Waimea.......	4	2RC24x48,12RM26x42...........	..	.....	.....	154	....	....	....	15.35	1.50	4	Waimea
Kipahulu......	44	K,5RM3-24x42,2-26x54..........	16	2 1/2	1	....	....	....	....	11.17	2.06	44	Kipahulu

* Tons cane per hour for one tandem. Ran as 15 roller mill 20% of the ti

† Tons cane per hour for one tandem.

‡ 6th mill opening 1x0, 7th mill opening ½x0. Returner bar clearance 6t

¶ 6th mill opening ½x0, 7th mill opening 1/16x0. Returner bar clearance—c

Factory	Factory No.	MILLING PLANT (Sizes in Inches)	First Set: Number	First Set: Distance Apart Inches	First Set: Distance from Conveyor Inches	ROLLERS—TONS: 4th Mill	5th Mill	6th Mill	7th Mill	Tons Cane per Hour	Tonnage Ratio	Factory No.	Factory
H. C. & S. Co..	6	K(2),2RC34x78,S72,12RM34x78..	28	9	24	525	....	....	....	58.08*	1.59	6	H. C. & S.Co.
" ..	6	K(2),2RC34x78,S72,12RM34x78..	28	9	24	525	....	....	....			6	"
Oahu..........	20	K,2RC32x78,12RM34x78.........	26	4	24	462	....	....	....	56.39†	1.60	20	Oahu
"	20	K,2RC35x78,S72,12RM34x78.....	11	7	5	473	....	....	....			20	"
Ewa..........	5	K(2),20RM2-32x78,18-34x78.....	72	.....	10	379	406	403	378	60.23	1.22	5	Ewa
Maui Agr......	21	K(2),21RM34x66..............	72	7/8	10	486	260	230	380	59.73	1.69	21	Maui Agr.
Pioneer.......	10	K,2RC34x72,S72,15RM34x72.....	27	2 1/4	8	360	375	....	....	61.40	1.71	10	Pioneer
Waialua.......	17	K(2),14RM2-33x78,12-34x78......	50	5 1/4	12	420	420	....	....	51.80	1.47	17	Waialua
Haw. Sug.....	16	K,2RC26x72,S72,12RM34x78.....	38	1 1/2	8	480	....	....	....	42.39	1.20	16	Haw. Sug.
Olaa..........	36	K,S72,12RM34x78..............	46	.....	5	410	....	....	....	49.56	1.76	36	Olaa
Honolulu......	13	K(2),S54,11RM34x78...........	24	6	18	450	....	....	....	34.76	1.23	13	Honolulu
Onomea.......	34	2RC28x60,S54,12RM32x66.......	..	.....	.....	418	....	....	....	37.03	1.47	34	Onomea
Hakalau......	7	2RC24x54,12RM9-32x60,3-32x66..	..	.....	.....	380	....	....	....	29.60	1.42	7	Hakalau
Kekaha.......	25	2RC24x54,9RM32x60............	..	.....	.....	....	....	....	....	28.98	1.74	25	Kekaha
McBryde......	12	K,S54,9RM34x84..............	24	6	4	....	....	....	....	35.33	1.44	12	McBryde
Hilo..........	33	K,2RC24x60,12RM32x66.........	10	6	10	430	....	....	....	35.89	1.42	33	Hilo
Wailuku.......	2	K,2RC26x72,12RM34x78.........	10	6	18	420	....	....	....	39.30	1.12	2	Wailuku
Haw. Agr.....	30	3RC32x60,12RM32x66...........	..	.....	.....	504	....	....	....	45.79	1.82	30	Haw. Agr.
Lihue.........	27	K,2RC26x72,S72,12RM34x78.....	10	6	11	480	....	....	....	45.15	1.28	27	Lihue
Lihue, Han....	46	K,2RC26x72,9RM34x78..........	11	6 1/4	10	....	....	....	....	33.65	1.18	46	Lihue, Han.
Waaikea......	3	K,S42,11RM2-28x60,9-32x60......	38	3	2	272	....	....	....	22.34	1.57	3	Waiakea
Makee........	14	K,2RC34x72,S72,9RM34x72......	12	6	30	....	....	....	....	41.50	1.73	14	Makee
Honokaa......	35	K(2),14RM2-30x60,12-32x66.....	68	1 3/4	16	321	395	....	....	31.89	1.27	35	Honokaa
Laupahoehoe..	41	K(2),11RM2-30x60,9-32x60......	16	3 3/4	1 1/4	373	....	....	....	25.73	1.54	41	Laupahoehoe
Pepeekeo......	19	2RC24x54,9RM6-32x60,3-30x60...	..	.....	.....	....	....	....	....	25.63	1.54	19	Pepeekeo
Kahuku.......	43	3RC30x60,S54,9RM34x72........	..	.....	.....	....	....	....	....	22.02	0.92	43	Kahuku
Koloa.........	38	K,2RC24x60,12RM32x66.........	24	6	6	400	....	....	....	32.21	1.28	38	Koloa
Hamakua......	15	K,2RC31x60,12RM32x60.........	60	1	1 1/2	331	....	....	....	22.96	1.10	15	Hamakua
Hawi.........	26	K,3RC26x48,12RM3-26x48,9-30x54	14	3 1/4	1 1/4	300	....	....	....	30.31	1.13	26	Hawi
"	26	K(2),S42,9RM30x54............	8	7	6	....	....	....	....			26	"
Paauhau.......	24	2RC24x60,12RM32x66...........	..	.....	.....	408	....	....	....	26.98	1.07	24	Paauhau
Honomu.......	37	2RC30x60,9RM32x60............	..	.....	.....	....	....	....	....	21.55	1.29	37	Honomu
Hutchinson....	31	2RC30x60,9RM32x60............	..	.....	.....	....	....	....	....	26.12	1.57	31	Hutchinson
Kaeleku.......	47	K(2),11RM2-24x54,9-32x60......	9	5 1/2	8	354	....	....	....	23.95	1.44	47	Kaeleku
Kohala........	40	K(2),S42,11RM2-30x60,9-32x60...	12	4	18	380	....	....	....	24.73	1.48	40	Kohala
Kaiwiki.......	32	K(2),11RM2-26x60,9-32x60......	18	3	1 1/2	368	....	....	....	22.23	1.33	32	Kaiwiki
Waianae......	9	K,12RM9-30x60,3-32x60.........	12	4 1/2	8	347	....	....	....	26.32	1.58	9	Waianae
Kilauea.......	23	K,S,3RC31x60,9RM32x60........	10	6	1 1/2	....	....	....	....	25.43	1.52	23	Kilauea
Waimanalo....	1	K,8RM6-26x54,2-30x60..........	8	6	8	....	....	....	....	17.18	1.69	1	Waimanalo
Niulii.........	39	K(2),9RM30x54................	9	.....	3 3/4	....	....	....	....	13.12	1.30	39	Niulii
Halawa.......	29	K,2RC30x60,6RM26x50..........	20	4	3	....	....	....	....	14.07	1.39	29	Halawa
Union Mill....	11	K,9RM30x60...................	16	3 7/8	3 1/2	....	....	....	....	18.31	1.46	11	Union Mill
Olowalu.......	18	K,3RC28x48,9RM27x48..........	16	3	2 1/4	....	....	....	....	16.06	1.51	18	Olowalu
Waimea.......	4	2RC24x48,12RM26x42...........	..	.....	.....	154	....	....	....	15.35	1.50	4	Waimea
Kipahulu......	44	K,5RM3-24x42,2-26x54..........	16	2 1/2	1	....	....	....	....	11.17	2.06	44	Kipahulu

* Tons cane per hour for one tandem. Ran as 15 roller mill 20% of the ti

† Tons cane per hour for one tandem.

‡ 6th mill opening 1x0, 7th mill opening ½x0. Returner bar clearance 6t

¶ 6th mill opening ½x0, 7th mill opening 1/16x0. Returner bar clearance—